Can You Copperplate?

Provided by TryEngineering - www.tryengineering.org

Lesson Focus

Lesson explores chemical engineering and explores how the processes of chemical plating and electroplating have impacted many industries. Students work in teams to copper plate a range of items using everyday materials. They develop a hypothesis about which materials and surface preparations will result in the best copper plate, present their plans to the class, test their process, evaluate their results and those of classmates, and share observations with their class.

Lesson Synopsis

The "Can You Copperplate?" lesson explores how engineers work to solve the challenges of a society, such as adjusting the surface of a metal to achieve a particular goal or outcome. Students work in teams to devise two systems for plating metal objects with copper. The teams develop their strategies, present them to the class, conduct a test to see which strategy worked best, reflect on the challenge, and present their findings to their class.

Age Levels

12-18.

Objectives

- Learn about engineering design and redesign.
- Learn about chemical engineering.
- Learn how engineering can help solve society's challenges.
- Learn about teamwork and problem solving.

Anticipated Learner Outcomes

As a result of this activity, students should develop an understanding of:

- chemical engineering
- chemical plating and electroplating
- safety and society
- teamwork

Lesson Activities

Students explore how engineers have solved societal problems such as developing and improving metal parts by adding a layer of another material to the surface. Students work in teams to develop a chemical system to add a layer of copper to another metal product. They test and evaluate their own results and the results of other teams, and share their reflections with the class.

Resources / Materials

- Teacher Resource Documents (attached)
- Student Resource Sheet (attached)
- Student Worksheet (attached)

Alignment to Curriculum Frameworks

See curriculum alignment sheet at end of lesson.

Internet Connections

- TryEngineering (www.tryengineering.org)
- Euro Copper Content (www.copperinfo.co.uk/coins/)
- Metal Finishing Magazine (www.metalfinishing.com)
- NASA Corrosion Technology Laboratory (http://corrosion.ksc.nasa.gov)
- Curriculum links (www.acara.edu.au)

Recommended Reading

- Modern Electro Plating (ISBN: 978-1149471944)
- The Polishing and Plating of Metals (ISBN: 978-1246867176)
- Electro-deposition of Metals (ISBN: 978-1176590250)

Optional Writing Activity

- Write an essay or a paragraph about why nails used in construction are galvanized.

Optional Extension Activity

- Have older students try electroplating the copper in a lab setting.

Safety Precautions

- Have students wear gloves when removing the materials from solution, or when disposing of solution.
- This activity should be done in a well-ventilated area as the solution can give off an odor after the plating process.

Can You Copperplate?

For Teachers:
Teacher Resources

◆ Lesson Goal
The "Can You Copperplate?" lesson explores how engineers work to solve the challenges of a society, such as adjusting the surface of a metal to achieve a particular goal or outcome. Students work in teams to devise two systems for plating metal objects with copper. The develop their strategies, present these to the class, conduct a test to see which strategy worked best, reflect on the challenge, and present their findings to their class.

◆ Lesson Objectives
- Learn about engineering design and redesign.
- Learn about chemical engineering.
- Learn how engineering can help solve society's challenges.
- Learn about teamwork and problem solving.

◆ Materials
- Student Resource Sheets
- Student Worksheets
- Classroom Materials (water source, bucket or sink area -- dirty coins or materials with a high copper surface content)
- Student Team Materials: glass jar, 25 coins with copper coating, other coins, iron nail or screw, aluminum bolts, salt, white/clear vinegar, lemon juice, baking soda, scouring pad, water, metal paperclips, other non-valuable metal items for students to experiment with.

◆ Procedure
1. Show students the student reference sheets. These may be read in class or provided as reading material for the prior night's homework.
2. To introduce the lesson, consider showing students several different screws or bolts with different finishes and ask them why different finishes are manufactured.
3. Teams of 3-4 students will consider their challenge, and develop two different plans for plating one of their items. They may use different solutions, materials, timings, etc…but each must incorporate a pile of older coins or materials with high external copper content - and use a glass container. (see www.copperinfo.co.uk/coins for EUROs)
4. Teams then present their two plans to the class.
5. Students may revise their plan, then conduct their two tests, and observe their results and those of other teams.
6. Teams reflect on the challenge, and present their experiences to the class.

◆ Time Needed
One to two 45 minute sessions.

◆ Notes and Cautions
1. Do not use valuable coins in this lesson as the finish will be altered and may impact collectible coin value.
2. Students should not drink the lemon juice or vinegar solution either before or after coins have been submerged; wearing gloves and goggles is recommended.

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For Teachers:
Teacher Resources

◆ **Teacher Tips**

Several methods will be successful at removing a layer of copper from the coins or other copper surfaced items and transferring the copper to another metal item. See a suggested solution below --- consider if you want to provide these methods to the teams or whether you would like teams to come up with a solution on their own.

Be sure to review and supervise ALL solutions developed for safety.

Solution:

Put 25 older/dirty coins (or materials with high external copper content) into a glass jar with 1/2 cup (125 ml) of white vinegar and 1/4 teaspoon (1ml) of salt. Let sit for 5 minutes, then add an iron nail, screw, or other item (Not galvanized). Be sure to clear the iron item first -- you can use a sponge with baking soda on it, or scrub with a steel wool pad so the surface is exposed. Let coins and iron item soak for 15 minutes. Pennies should be shiny and nail should have thin coating of copper.

Notes:

- You can substitute lemon or orange juice for the white vinegar. Students will be able to see what is happening better with the vinegar or lemon juice.
- Dispose of resulting liquid in a sink (can be a smelly mixture).
- If the coins are not rinsed in water after the experiment, they will turn blue-green after a few days.

Why does this work?

Copper oxide will dissolve when exposed to the acid solution resulting from the mixture of vinegar and salt

After the experiment, unrinsed coins will turn green in a few days because when exposed to the acid and left to air dry, the exposed copper atoms will react with oxygen and remaining salt to make blue-green malachite.

The iron materials are coated with copper because when the coins are in the solution some of the surface copper will dissolve. But when copper atoms leave the coin, they leave some of their electrons behind….really positively charged copper ions (copper atoms that are missing two electrons). Likewise, some of the metal in the iron dissolves and there are positively charged iron ions floating in solution with the positively charged copper ions. When the iron ions leave the nail/screw, the item becomes negatively charged and so attracts the positively charged ions in solution. Copper ions are more strongly attracted to the iron item than the iron atoms, so they coat the item with a thin coating of copper.

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Student Resource: Chemical Engineering

◆ What do Chemical Engineers do?

Chemical engineers apply the principles of chemistry to solve problems involving the production or use of chemicals and other products. They design equipment and processes for large-scale chemical manufacturing, plan and test methods of manufacturing products and treating byproducts, and supervise production.

◆ Where do Chemical Engineers Work?

Chemical engineers work in manufacturing, pharmaceuticals, healthcare, design and construction, pulp and paper, petrochemicals, food processing, specialty chemicals, polymers, biotechnology, and environmental health and safety industries, among others. Within these industries, chemical engineers rely on their knowledge of mathematics and science, particularly chemistry, to overcome technical problems safely and economically. And, of course, they draw upon and apply their engineering knowledge to solve any technical challenges they encounters.

Chemical engineers also work in a variety of manufacturing industries other than chemical manufacturing, such as those producing energy, electronics, food, clothing, and paper. In addition, they work in healthcare, biotechnology, and business services. Chemical engineers apply principles of physics, mathematics, and mechanical and electrical engineering, as well as chemistry. Some may specialize in a particular chemical process, such as oxidation or polymerisation. Others specialise in a particular field, such as nanomaterials, or in the development of specific products. They must be aware of all aspects of chemical manufacturing and how the manufacturing process affects the environment and the safety of workers and consumers.

Chemical engineers typically do the following:

- Develop safety procedures for those working with potentially dangerous chemicals
- Troubleshoot problems with manufacturing processes
- Evaluate equipment and processes to ensure compliance with safety and environmental regulations
- Conduct research to develop new and improved manufacturing processes
- Design and plan the layout of equipment
- Do tests and monitor performance of processes throughout production
- Estimate production costs for management
- Develop processes to separate components of liquids or gases or to generate electrical currents using controlled chemical processes

(Note: Some resources in this section provided by the Sloan Career Cornerstone Center - www.careercornerstone.org - and the U.S. Bureau of Labor Statistics.)

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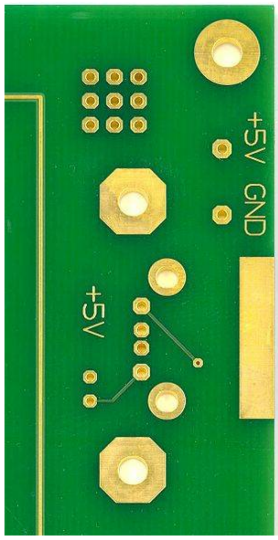
Student Resource: Plating Processes

◆ Metal Plating

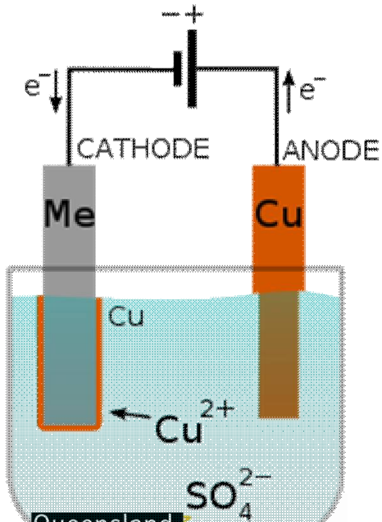
Plating of metals has been done via many processes since ancient times. Gold plating is a method of depositing a thin layer of gold onto the surface of another metal, most often copper or silver (to make silver-gilt), by chemical or electrochemical plating.



Electroplating has many uses….it can make a material more resistant to damage or abrasion….it can make a material look nicer….to harden a surface…to reduce friction….to improve paint adhesion, to alter conductivity, for radiation shielding, and for other purposes. It is also used to build up the thickness of undersized parts. It is widely used in industry for coating metal objects with a thin layer of a different metal. The layer of metal deposited has some desired property, which the metal of the object lacks. For example, chromium plating is done on many objects such as car parts, bath taps, kitchen gas burners, wheel rims and many others. Gold is often plated onto silver or a less expensive metal to reduce the cost of jewelry. Gold plating is often used in electronics, to provide a corrosion-resistant electrically conductive layer on copper, typically in electrical connectors and printed circuit boards. The surface of nails used in construction are sometimes galvanised which adds a layer of zinc.

◆ What is Electroplating?

Electroplating is a process in which metal ions in a solution are moved by an electric field to coat an electrode. The process uses electrical current to coat a conductive object with a thin layer of the material, such as a metal. The process used in electroplating is called electrodeposition. In one technique, the anode is made of the metal to be plated on the part. Both components are immersed in a solution called an electrolyte containing one or more dissolved metal salts as well as other ions that permit the flow of electricity. A power supply supplies a direct current to the anode, oxidizing the metal atoms that comprise it and allowing them to dissolve in the solution.



At the cathode, the dissolved metal ions in the electrolyte solution are reduced at the interface between the solution and the cathode, such that they "plate out" onto the cathode. The rate at which the anode is dissolved is equal to the rate at which the cathode is plated, vice-a-versa the current flowing through the circuit. In this manner, the ions in the electrolyte bath are continuously replenished by the anode.
In the example to the right, in an acid solution, copper is oxidized at the anode to Cu^{2+} by losing two electrons. The Cu^{2+} associates with the anion SO_4^{2-} in the solution to form copper sulfate.

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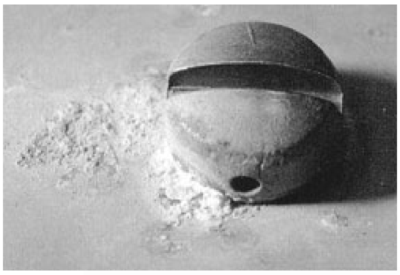
Student Resource: Galvanic Corrosion

◆ Galvanic Corrosion

Galvanic corrosion is an electrochemical action of two dissimilar metals in the presence of an electrolyte and an electron conductive path. It occurs when dissimilar metals are in contact. When this happens, you'll see a buildup of corrosion at the joint between the dissimilar metals.

The galvanic series (or electropotential series) is a scale that shows the nobility of metals and semi-metals. The farther apart the metals are in the galvanic series, the greater the galvanic corrosion effect or rate will be. Metals or alloys at the upper end are noble while those at the lower end are active. The more active metal is the anode or the one that will corrode. Control of galvanic corrosion is achieved by using metals closer to each other in the galvanic series or by electrically isolating metals from each other. Galvanic reaction is the principle upon which batteries are based.



NASA's Corrosion Technology Laboratory conducts research on the effects of galvanic corrosion. The photo at the right shows the corrosion caused by a stainless steel screw causing galvanic corrosion of aluminum. Find out more at http://corrosion.ksc.nasa.gov.

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Student Worksheet:

◆ **Engineering Teamwork and Planning**

You are part of a team of engineers given the challenge of applying a copper surface to another metal. You can choose the metal item/items you want to plate and also the chemical solution and timing you think will work best. You will develop two different approaches and see which works best.

Step 1: Determine two methods for copper plating and identify your items. Note, you may wish to consider placing multiple items in one of the solutions...but be aware that any copper released from the coins or other copper based items you have will then be diluted between multiple metal items and so you may not see results. In the box below, describe your solution, method, timing, and the items you will copper plate.

Solution	Describe Solution (include quantity of each item you will include)	Describe items to be plated	Describe method (including timing, rinsing methods, etc.)	Anticipated Result
1				
2				

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Student Worksheet:

◆ **Presentation and Testing**

Step 2: Present your plan and anticipated outcome to the class. Consider the ideas of the other teams and adjust your plan if you like.

Step 3: Test your two methods and note your observations in the box below.

Solution	What Happened to the Solution?	What Happened to the Item you were trying to plate?	What happened to the pennies or copper surfaced items/coins?	Did this method work?
1				
2				

Student Worksheet:

◆ **Reflection**

Complete the reflection questions below:

1. Was your team able to copperplate a metal item? What factors do you think contributed to the success or failure of your method?

2. If you found you needed to make changes to your method after listening to the methods planned by other teams, describe why your team decided to make revisions.

3. Which method that another team adopted was the most successful? Why do you think this method worked so well?

4. Do you think that this activity was more rewarding to do as a team, or would you have preferred to work alone on it? Why?

5. Do you think that chemical engineers have to make many attempts to achieve a goal? What do you think it would be like to fail over and over before having success?

6. What industry or business do you think might want to use the method you developed?

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For Teachers:
Alignment to Curriculum Frameworks

Science Understanding

Year 9

Chemical reactions involve rearranging atoms to form new substances; during a chemical reaction mass is not created or destroyed **(ACSSU178)**

Chemical reactions, including combustion and the reaction with acids, are important in both non-living and living systems and involve energy transfer **(ACSSU179)**

Year 10

Different types of chemical reaction are used to produce a range of products and can occur at different rates **(ACSSU187)**

Science Inquiry Skills

Year 9

Plan, select and use appropriate investigation methods, including fieldwork and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods **(ACSIS165)**

Select and use appropriate equipment, including digital technologies, to systematically and accurately collect and record data **(ACSIS166)**

Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data **(ACSIS171)**

Year 10

Plan, select and use appropriate investigation methods, including fieldwork and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods **(ACSIS199)**

Select and use appropriate equipment, including digital technologies, to systematically and accurately collect and record data **(ACSIS200)**

Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data **(ACSIS205)**

Science as a Human Endeavour

Year 9

Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries **(ACSHE158)**

Advances in science and emerging sciences and technologies can significantly affect people's lives, including generating new career opportunities **(ACSHE161)**

Year 10

Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries **(ACSHE192)**

Advances in science and emerging sciences and technologies can significantly affect people's lives, including generating new career opportunities **(ACSHE195)**

Mathematics Links with Science Curriculum (Skills used in this activity)	General Capabilities	Cross-Curriculum Priorities
• Process data using simple tables • Data analysis skills (graphs) • Analysis of patterns and trends • Use of metric units	• Literacy • Numeracy • Critical and creative thinking • Personal and social capacity • ICT capability	• Sustainability

Science Achievement Standards

Year 9

By the end of Year 9, students ***explain chemical processes*** and natural radioactivity ***in terms of atoms and energy transfers and describe examples of important chemical reactions***. They describe models of energy transfer and apply these to explain phenomena. They explain global features and events in terms of geological processes and timescales. They analyse how biological systems function and respond to external changes with reference to interdependencies, energy transfers and flows of matter. They describe social and technological factors that have influenced scientific developments and predict how future applications of science and technology may affect people's lives.

Students design questions that can be investigated using a range of inquiry skills. ***They design methods that include the control and accurate measurement of variables and systematic collection of data and describe how they considered ethics and safety. They analyse trend in data, identify relationships between variables and reveal inconsistencies in results. They analyse their methods and the quality of their data, and explain specific actions to improve the quality of their evidence***. They evaluate others 'methods and explanations from a scientific perspective and use appropriate language and representations when communicating their findings and ideas to specific audiences.

Year 10

By the end of Year 10, students analyse how the periodic table organises elements and use it to make predictions about the properties of elements. ***They explain how chemical reactions are used to produce particular products and how different factors influence the rate of reactions***. They explain the concept of energy conservation and represent energy transfer and transformation within systems. They apply relationships between force, mass and acceleration to predict changes in the motions of objects. Students describe and analyse interactions and cycles within and between Earth's spheres. They evaluate the evidence for scientific theories that explain the origin of the universe and the diversity of life on Earth. They explain the processes that underpin heredity and evolution. Students analyse how the models and theories they use have developed over time and discuss the factors that prompted their view.

Students develop questions and hypotheses and independently design and improve appropriate methods of investigation, including field work and laboratory experimentation. They explain how they have considered reliability, safety, fairness and ethical actions in their methods and identify where digital technologies can be used to enhance the quality of their data. When analysing data, selecting evidence and developing and justifying conclusions, they identify alternative explanations for findings and explain any sources of uncertainty. Students evaluate the validity and reliability of claims made in secondary sources with reference to currently held scientific views, the quality of methodology and the evidence cited. They construct evidence-based arguments and select appropriate representations and text types to communicate science ideas for specific purposes.