Aluminazing

One of the most common minerals on the planet is also one of the most versatile.

GRADES 9-12

ISRI
Voice of the Recycling Industry

JASON Learning

PREPARE:

Time Required: 2 class periods (90 minutes) without extension

- Gather materials (see activity pages).
- Make copies of the activity pages (one per student).
- Have SDS information on all chemicals available.
- Ensure that students understand all safety precautions in advance.
- Collect a variety of materials that might contain aluminum (deodorants, toothpastes and styptic pencils (alum), foods (pickles), cookware and foil food wrappers, playdough and other toy products, components of cars and bicycles, and construction elements.
- Confirm students will have access to computers and internet.

For the demonstration of the anodizing process the instructor will need the following materials:

- 400 ml beaker containing ~300 ml 3 M H_2SO_4
- Ring stand and clamps for each aluminum strip
- 10 Volt Power Supply
- Impact/chemical eye protection
- Wires with clips for the power supply
- Hot plate
- Forceps
- Paper Towels
- Fume hood
- Periodic table

MOTIVATE:

- Before showing them the objects you have collected, have students brainstorm items they may have come across today that they think might contain aluminum.
- Keep a class list on the board.
- Show students the items you have collected.
- Ask students which of the properties of aluminum make it a good choice to use in each of the products? (At this point, students will not need extensive information but to complete the student activity they will research further).

TEACH:

- Explain to students that aluminum is found in group 13 (13 protons, 14 neutrons) of the Periodic Table. While it sits under Boron, the other elements in that group more closely match aluminum in properties. It is the third most abundant element in Earth's crust, found in significant quantities in Australia, India, Jamaica, and China.
- Aluminum is not only a valuable ore for chemical products and metal construction, but is also the most easily and completely recyclable product used by American households. It takes only 1/20th as much energy to make a soda can out of recycled aluminum than out of new ore, and the process can occur again and again without any loss of quality or amount. Recycled aluminum can also be made into medicines, building materials and even works of art!
- Have students complete the Examining Materials in Cars section of the student activity.
- Tell the students that they are going to look at the chemical properties of aluminum. The anodization process that you demonstrate here can be used to illustrate the durability of aluminum and the creative uses that can be developed for secondary aluminum products. It can also be used to provide the raw materials for interesting student artwork that can be used to promote recycling in the school.
- Caution: The demonstration involves highly caustic chemicals and procedures that must be done using sound safety precautions. Anodization should only be done by knowledgeable instructors in the appropriate facilities, with appropriate preparation, equipment, and space.
- Follow the process described in the teacher pages and demonstrate anodization. Vary the amount of time for the strips so there will be a difference in how they dye.

REFLECT/ASSESS

Students should be able to:

- Explain why the strips should be clean. **This will remove oil and other dirt that might interfere with the process.**
- In the demonstration identify the anode, cathode, and electrolyte. **The anode is the small aluminum strip; the cathode is the aluminum sheet. The acid solution is the electrolyte.**
- Understand why the strips took the dye in different ways. **The longer anodization times normally result in more receptivity to the dye.**

EXTEND

Photograph aluminum products in your community. This might include the roof of a civic building, a work of art, or a vehicle. Create a visual "ad" (poster, power point or social media video) that conveys the message: "Your recycled can can become this!"

JOURNAL QUESTION

Manufacturers are enthusiastic about the potential for even more and better uses for aluminum. Can you think of some new and unique uses for aluminum? What properties of aluminum make it ideal for this use?

Aluminazing

Background

Non-ferrous metals like aluminum, copper, lead, nickel, tin, and zinc are especially valuable to recycle. They are among the few materials that do not degrade in recycling. Aluminum cans are used all over the country.

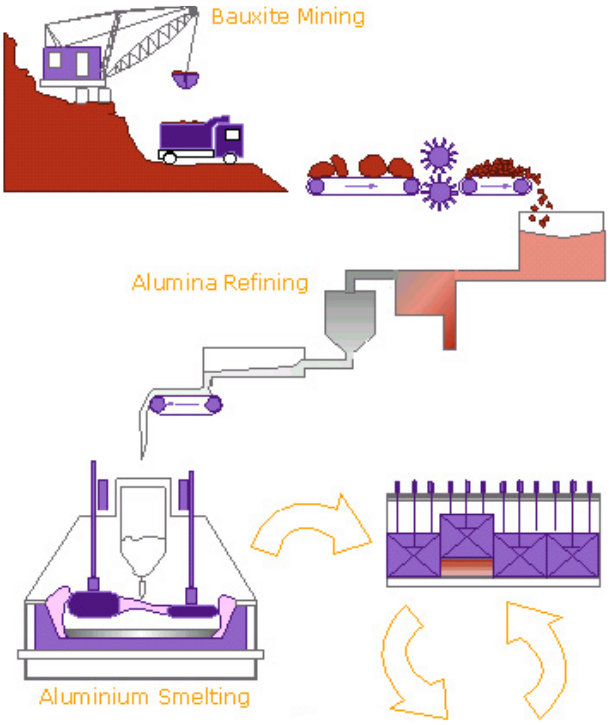
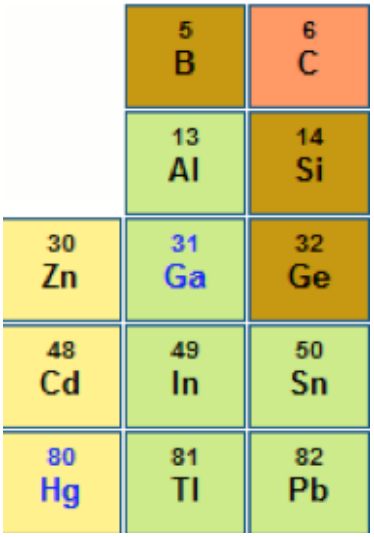


Image Credit: Princeton University



More than $40 billion in non-ferrous metals are recycled each year. ISRI estimates that if all the aluminum scraps that we recycle were made into cans, they would stretch from Earth to Venus! And recycling saves enormous amounts of energy, the equivalent of 25 million barrels of gasoline a year. Replacing some iron or steel components of our vehicles with strong alloys of aluminum would save even more energy.

The bauxite ore, which is mined to produce aluminum, is almost always strip-mined; topsoil and lumber are removed and the next level of soil (overburden) is removed. The ore is found in the caprock layer. This forms a hard sheet that must be broken by blasting or heavy equipment. About 100 million tons of bauxite are mined each year worldwide. After mining, bauxite is processed into aluminum oxide and then converted to alumina by the process of hydrolysis.

The Anodization Process

Caution ⚠ The demonstration involves highly caustic chemicals and procedures that must be done using sound safety precautions. It should only be done by knowledgeable instructors in the appropriate facilities, with appropriate preparation, equipment, and space.

In the demonstration detailed here, students will provide aluminum strips, which they have obtained from cans or other products. The instructor will anodize them to demonstrate the potential for a wider variety of products. Then students can dye the strips and demonstrate their creativity in developing positive recycling messages.

Anodizing Aluminum

1. Preparing the cell for electrochemistry demonstration
   A. Test your 10 V battery.
   B. Do all anodization in a fume hood with appropriate safety equipment.
   C. Make sure that all the aluminum you will be using is cleaned of all surface oil or dirt. If students cut their own strips from aluminum products, wipe the strips clean with acetone and dry. (Acetone is flammable! Proper disposal is necessary.)

D. The anode for the process will be an aluminum strip 1 cm x 8 cm. It will be connected to the positive (+) side of the power supply (after all safety precautions have been checked.)
E. The cathode will be an aluminum sheet 10 cm by 20 cm rolled so that it fits loosely into a 400 ml. beaker. It will be connected to the negative (-) side of the power supply (after all safety precautions have been checked.)
F. The electrolyte is 3 M sulfuric acid. (This is highly caustic. Do not bring the stock bottle into the classroom. Label appropriately. Have SDS information and safety equipment available. Eye protection and gloves are required. All students should observe safety precautions even though this will be a demonstration.)
G. Begin the anodization process
   - Check that your power supply is off.
   - Connect the alligator clip from the negative terminal to the aluminum sheet.
   - Connect the alligator clip from the positive terminal to the small aluminum strip.
   - Submerge the strips in the sulfuric acid.
   - Check all connections and procedures before turning on the power supply.
   - Run the power supply for 5 minutes and record your observations.
   - Repeat with additional strips for 10 minutes.
   - Carefully remove the strips. (Caution! They have acid on them. Gloves, forceps and eye protection required.) Remove all acid.
   - Dispose of acid per proper disposal methods in your school. (Never add water to acid)

Student Answers to Part 1 - Examining Materials in Cars

Material found in a 567 kg car	Percent 1980 car	Percent 2008 car	Mass in kg	Mass in kg
Plastic	7	9	40	51
Aluminum	4	8	23	45
Steel	56	55	318	312
Iron	15	7	85	40
Other	18	21	102	119

2. 34k
3. Tensile strength, stiffness and durability
4. About 41,000 cans

Aluminazing

Aluminum is not only a valuable ore for chemical products and metal construction, but is also the most easily and completely recyclable product used by American households. It takes only 1/20th as much energy to make a soda can out of recycled aluminum than out of new ore, and the process can occur again and again without any loss of quality. Recycled aluminum can also be made into medicines, building materials and even works of art! In this activity you will examine the use of aluminum in cars as well as how create a work of art from a strip of anodized aluminum.

Materials

- Goggles for eye protection
- Metal cutters
- Gloves
- Aluminum cans
- Acetone and paper towels
- Single hole punch
- Rit dye – various colors
- Water
- Vinegar
- Container for dye

Part I: Examining Materials in Cars

1. Examine the graphs and table in the student data sheet.
2. Calculate the mass in grams of each of the materials used in the cars. Record your calculations in the table, and an-swer the questions on the student data sheet.
3. Use the Online Metals Weight Calculator at http://www.onlinemetals.com/calculator.cfm to help verify your estimations.

Part II: Anodizing Aluminum

1. Put on eye protection goggles.
2. From your recycled can, carefully cut a strip of aluminum approximately 1cm x 6 cm.
3. Clean your strips with a mild acetone solution and give them to the instructor.
4. The instructor will describe and demonstrate the anodization process in a fume hood. During the process make observations to share with the class.
5. When the anodization is done and the chemicals properly stored, you will get your strips back.
6. Again, wearing you eye protection goggles; mix the dye according to the directions.
7. Submerge your strips in a dye bath for 5-10 minutes.
8. Carefully remove your strips and rinse and dry.
9. Now is your chance to be creative. Work with your class and design a product with the strips that would advertise, “What a recycled can can do!” .

Reflect and Apply

1. Why should the strips be clean?
2. In the demonstration, what is the anode? The cathode? The electrolyte?
3. Why conclusions can you make about the different ways in which the strips were colored by the dye?
4. What observations did you make during the anodization process?

Extension

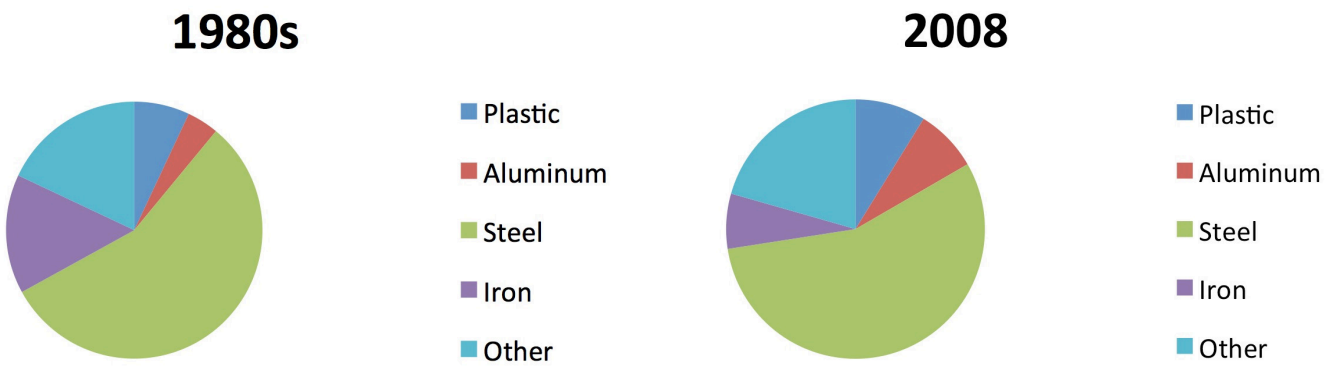
Photograph aluminum products in your community. This might include the roof of a civic building, a work of art, or a vehicle. Create a visual "ad" (poster, power point or social media video) that conveys the message: "Your recycled can can become this!"

JOURNAL QUESTION

Manufacturers are enthusiastic about the potential for even more and better uses for aluminum. Can you think of some original uses for the aluminum? What properties of aluminum make it ideal for this use?

Recycling Activities Collection — Aluminazing

Student Name: Period:



Complete the table below by calculating the mass of each of the materials used in a car in 1980 and a car of the same size in 2008.

Material found in a 567 kg car	Percentage in a 1980 car	Percentage in a 2008 car	Mass (kg) of Material in a 1980 car	Mass (kg) of Material in a 2008 car
Plastic	7	9		
Aluminum	4	8		
Steel	56	55		
Iron	15	7		
Other	18	21		

1. On average, iron and steel weigh three times as much as the most common alloy of aluminum that would be used in auto construction. If you assume that the iron and steel components have been replaced by aluminum, how much mass has been saved?

2. Could more steel be replaced by aluminum? Engineers look at not only the mass of the product but its strength. One common component is called “6061” It can approach the strength of steel, but you may need more aluminum (as much as three times) to create as strong a vehicle. What other properties might engineers need to consider as they replace iron and steel with aluminum?

3. About 73 aluminum cans weigh a kilogram. How many recycled cans would be needed to provide the aluminum for a modern small car?