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DIY Chemistry

or

engaging activities for making stuff with Chemistry

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Introduction

In a digital, connected world, one could imagine that more and more people would stop making things in the real world. The DIY movement has shown that the opposite is happening: more and more people are engaging in creating new things and sharing the instructions in the internet. Web sites like Instructables (www.instructables.com) have thousands of ideas from how to make a sandwich to how to hack your telephone.

We can take some ideas from the DIY community and bring them to Chemistry teaching. Chemistry deals with the properties of materials and how they change. To make something it is important to understand the properties of materials, how they interact and where to find them. I am going to show a few experiments that show the importance of knowing Chemistry to make things. They allow the students to engage in activities that can be challenging, open and interesting and where the Chemistry they've learned can be applied to make something they can take home.

In some of the experiments, the students can customize the final product so it can show a personal touch. It is interesting to provide some way for the students to share what they made, be it on the internet or in an exhibit at the school.

I hope you enjoy these experiments!

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Carving a Can with Chemistry

Why carve a pumpkin if you can make a beautiful lantern with an aluminum can?

Material

Goggles, gloves
copper sulfate 1,0 mol/L
sodium chloride
aluminum can
compass or another tool with a sharp point
stencil
masking tape
Petri dish - larger diameter than the can - or any shallow dish of suitable size

Let´s do it

Aluminum cans are used for juices, soda and beer. The cans receive, on the inside, a plastic film that avoids the contact of the liquid with the metal. On the outside, the cans are painted with the brand's logo and other information. This external paint protects the aluminum surface from corrosion.
If we scratch the surface of the can with a pointy tool (we used the spike of a drafting compass), the aluminum surface will be exposed. If we find a suitable oxidizing agent, we can corrode the aluminum only in the parts of the can that were scratched.

Safety

We selected copper sulfate as the oxidizer. It is less toxic or dangerous than other alternatives, like using sodium hydroxide to react with the aluminum. Still, gloves and goggles should be used during the experiment. Students should be oriented to be careful with the pointy tool used to scratch the cans.

Select a stencil to help you scratch the can. You can pick a drawing, print it on an overhead projector transparency and cut it out. There are many free drawings available on the internet, specially with a Halloween theme. I usually ask the students in advance to bring their own stencils, ready for use. I also keep a small number of options ready for those that forget to bring their own.

After the contour of the drawing is scratched on the can, cover its top and bottom parts with masking tape. This will protect these parts, since they are not covered by paint. Now the can is ready for "carving". Put the copper sulfate solution in a shallow dish. Placing the can sideways, with the drawing facing down in the solution for a few seconds. You will notice that nothing happened at all! Put a teaspoon of sodium chloride in the copper sulfate solution and stir until it is dissolved. Place the can in the solution again for a few seconds. Now you will see a reddish-brown solid deposited on top of the drawing. Keep the part of the can with the scratched drawing in the solution for a few minutes. You can make the reaction go faster by removing the copper deposit with paper towels. After some time, all the aluminum along the edges of the drawing will have reacted and dissolved. The internal plastic covering will be still there, and you can remove it with the help of the pointy end of the compass.

Wash the can and let it dry. You can paint the can, using spray paint. Use a file to remove the top part of the can. Place a small candle inside. Your lantern is ready!

What's going on

When we place the can in the copper sulfate for the first time, we could expect it to react right away. After all, looking at the reaction:

$$2\ Al(s) + 3\ Cu^{2+}(aq) \rightarrow 2\ Al^{3+}(aq) + 3\ Cu(s)$$

and at a table of reduction potentials, everything seems right. Aluminum is indeed easier to oxidize than copper. Then why nothing happened? Even though we removed the paint covering the aluminum in the can, there is still a layer of aluminum oxide protecting the aluminum surface. We have to remove this layer for the copper ions to reach the aluminum metal. That is where the chloride ions enter. They help remove the oxide layer and let the copper ions react with the aluminum. You may also notice that during the reaction some bubbles can be seen. The aluminum also reacts with water, releasing hydrogen gas:

$$Al(s) + 3\ H_2O(l) \rightarrow Al(OH)_3(s) + 3/2\ H_2(g)$$

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Hydrophobic Toys

Material
candle, matches
piece of steel can
pliers
wood board
popsicle wood sticks

This activity is based on the article below. Please read it for an in-depth explanation of the chemistry involved.

New Nanotech from an Ancient Material: Chemistry Demonstrations Involving Carbon-Based Soot
Dean J. Campbell, Mark J. Andrews and Keith J. Stevenson
J. Chem. Educ. 2012, 89, 1280−1287

The article explains how a super-hydrophobic surface can be created by depositing carbon soot from the incomplete combustion of a hydrocarbon to metal or glass. A candle or a propane torch with the air opening closed can be used to generate the soot. You only have to bring a steel or aluminum can to the top of the flame and let it be coated with a uniform layer of carbon soot. Let it cool and place a few drops of water on top of the soot and you will see that it slides effortlessly.
We suggest two designs for toys based on the hydrophobic surfaces. The first one is a hydrophobic labyrinth. It is based on wood ball mazes, where a marble is led through the maze by inclining the toy. We made ours by gluing popsicle sticks to a wood board and covering everything with carbon soot. The second toy is a slide made from a steel can. We cut a long strip of the can and made a curved surface for the water drops to slide. By changing the height one can change the distance the water drops are thrown.

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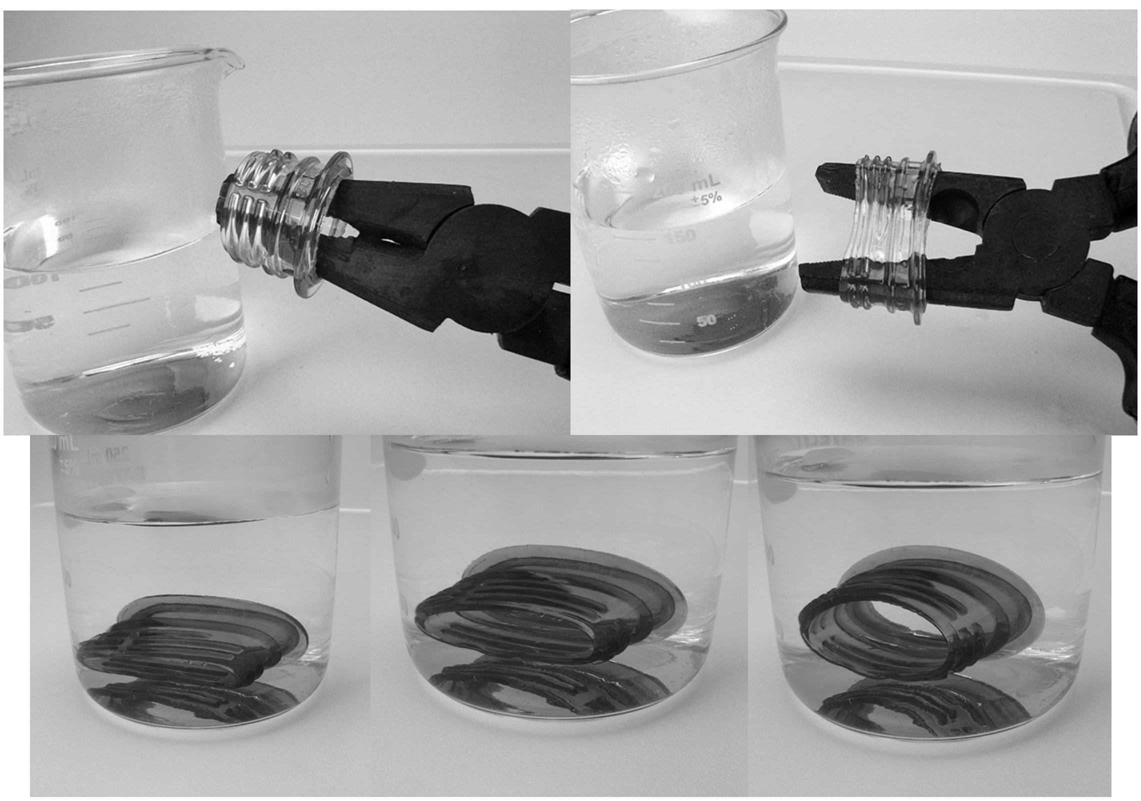
Plastics never forget

Material
PET bottle (#1 recycling code)
saw, pliers
250 mL beaker, immersion boiler (or microwave oven)
water

Let's do it
Cut the top part of the PET bottle, right below the screw, using a saw. Fill the beaker with around 150 mL of water. Boil the water on the beaker. Put the plastic screwtop in the hot water. After some seconds, remove the plastic piece with pliers. Place the pliers inside the ring and open them. Let the plastic ring cool down for a few seconds, close the pliers and examine the piece. Drop the plastic in the hot water again and observe. You will notice that the plastic returns to the cylindrical form spontaneously.

What's going on
PET (poly ethylene terephthalate) has a Glass Transition Temperature (Tg) around 90 ºC. That means that at that temperature the polymeric chains are able to move more freely one on top of the other. The material becomes flexible and we are able to stretch it. When it cools down, it becomes locked in the new shape. If we heat it again, it will release the tension that was placed in it and return to the previous shape. A rubber band works in the same way, but its Tg is much lower than for PET and it is flexible at room temperature. If you cool the rubber band down (with liquid nitrogen), it will become hard.



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Make your own soda bottle

Preform
1 beaker - 500 mL
immersion boiler (that fits inside the beaker) or microwave oven
thermal gloves
bycicle pump
bicycle tire valve
cap from a soda bottle

Let's do it
First, you need to prepare the cap, making a hole where the tire valve will fit tightly. Fill the preform 2/3 with water. If you have a microwave oven available, place the beaker with the preform and boil the water for a few seconds. If you’re using a boiler, boil the water and place the preform inside for a few seconds. Using gloves, screw the cap with the tire valve on the preform. Connect the bike pump to the valve and quickly pump air into the preform. This must be done fast, before the preform cools down. The preform will expand like a bubble. Let the “bottle” cool down before opening it.

What's going on

Plastic bottles are made by first preparing a preform by injection moulding. The preform is taken to the bottling plant and blown inside a mould with high pressure air. Before entering the mould, the preform is heated in an oven. A blow-moulding machine can make around 10 thousand bottles in an hour. The Glass Transition Temperature for PET is below the boiling point of water. Above this temperature, the polymer chains are able to move more freely and the material becomes flexible.