Enginearring

Dazzle Kids by Turning Dull Gray Titanium into Colorful Jewelry

by Jeffrey B. Nelson and Kavita M. Jeerage

"Enginearring" was developed for the University of Washington's Engineering Open House in 2004 and 2005. Audiences learn how electrochemistry creates thin titanium dioxide films on titanium, why the transparent films look colorful, and walk away with unique titanium jewelry (earrings or rings). It has been incredibly popular (thousands served) and memorable (this year, some visitors told us they'd been hearing about it all year). It requires a one-week time commitment to prepare and host an open house, but kids and parents will love it. The following recipe describes the procedures we developed. Variations on this recipe are possible.

Advance Preparation Time
4 people × 10 h each

You Will Need
shears to cut titanium, drill press, basic hand tools, power supply (1 A, 100 V)

Approximate Yield
800 pairs of earrings

Ingredients
2 earring racks (anodes)
1 stainless steel electrode (cathode)
2 titanium sheets (4 in. × 0.01 in. × 6 ft): approx. $250
clear plastic tub (7 × 13 × 5 in.)
5 wt % trisodium phosphate
fishing line
on/off switch
plexiglass cylinder (2.25 in. od and 15 in. long) cut in half lengthwise
1800 silver-plated earring hangers: $50-100
8-10 dedicated students during open house

Directions

1. Prepare the Electrodes

You will need to fabricate two earring racks with enough hooks to hold about 20 titanium strips on each rack. We chose stainless steel because it is inert and we found existing material in our machine shop. You will also need a large stainless steel counter electrode (we used a 9 × 3 in. sheet).

Helpful Hint: We made more hooks than needed because some get damaged during the exhibition.

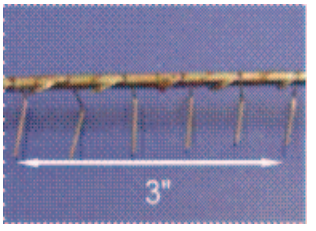

Fig. 1. *Close-up of earring rack.*

2. Prepare Titanium Strips

Cut titanium into 3/16 × 4 in. strips. You should have about 800 pieces. Make 3 dimples on each strip using a hammer and center punch (see photo for placement). Drill each hole using the dimples to guide the drill bit into place. Smooth the back side of drilled holes by pounding each one with the hammer once.

Helpful Hints: If you make the dimples too large, the hole might re-close when you pound it. Make sure the holes are large enough to fit around the earring rack hooks and purchased earring hangers.

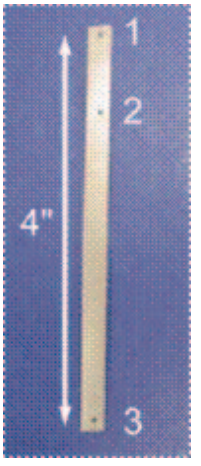

Fig. 2. *Titanium strip.*

3. Assemble Electrochemical Cell

The electrochemical cell is comprised of a plastic tub with three electrodes: the center electrode (cathode) is the stainless steel sheet and the outer electrodes (anodes) are titanium strips hanging from the earring racks (see Fig. 3).

Helpful Hint: You may need to notch the plastic tub to keep the racks in place.

Attach electrically insulating fishing line to each end of rack 2 so it can be raised and lowered into the solution during operation. Hang 5-15 titanium strips on each rack from hole 1 and place in cell. Fill the plastic tub with 5 wt % trisodium phosphate so the liquid level is above hole 2. Hook the negative terminal of the power supply to the stainless steel cathode. The positive terminal from the power supply should have separate leads to each earring rack. Attach an on/off switch in the lead to rack 1 so you can independently control it. We recommend you monitor the cell voltage.

SAFETY CONSIDERATIONS

This is a high current and high voltage process. Cover rack 1 and the stainless steel cathode with plexiglass safety shields (Fig. 3). These protect audience members from accidentally touching the electrodes and prevent short circuits.

4. Create Solid and Rainbow Colored Titanium

Set the applied current using Table I.

Helpful Hint: Current density changes during the process so exact values are not important.

Once the current is switched on, slowly raise rack 2 using the fishing line. When rack 1 (which remains immersed in solution) reaches a desired color, halt oxidation by toggling the on/off switch. Observed colors should roughly correspond to the voltages in the table. When rack 2 is nearly out of solution (1/4 to 1/2 in. still immersed), halt oxidation by shutting down the power supply.

Helpful Hint: Two people are needed to run the process as described.

The entire process requires 20-30 s. Water electrolysis will be observed as the color of the titanium changes. Due to high current densities, local heating may produce water vapor.

Helpful Hint: If you observe sparking at the hook/titanium interface, sand the inside of the hooks to remove salt buildup.

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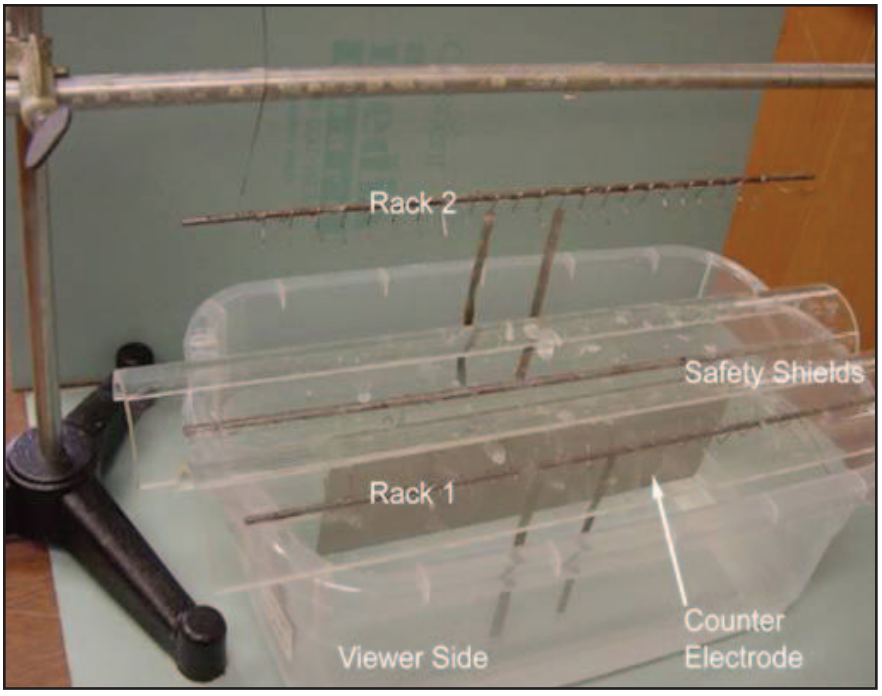

Fig. 3. *Electrochemical cell.*

Table I.

Strips (no.)	Current (mA)
5	325
10	575
15	795
20+	1000

Table II.

Color	Voltage
Gold	<10
Purple	10–20
Blue	30–40
Yellow	50–60
Violet	70–80
Green	>90

5. Finish Titanium Jewelry

Trim excess titanium above hole 2 and cut the remaining strip in half, as shown in Fig. 4. Shape as desired with needle-nose pliers and add earring hooks. For rings, trim all holes and twist with pliers.

6. Suggestions for an Open House

The electrochemical demonstration requires a room with controlled access. Position the electrochemical cell so there is at least 1 ft between it and the audience. Be sure to warn each group about keeping their hands away from the demonstration. As crowds gather outside the demo room, introduce the science using a large poster that explains why titanium dioxide films appear colorful and how we make them using electrochemistry. Our poster is geared to middle-school kids and is available at http://courses.washington.edu/dtsclass/Kthru12.htm.

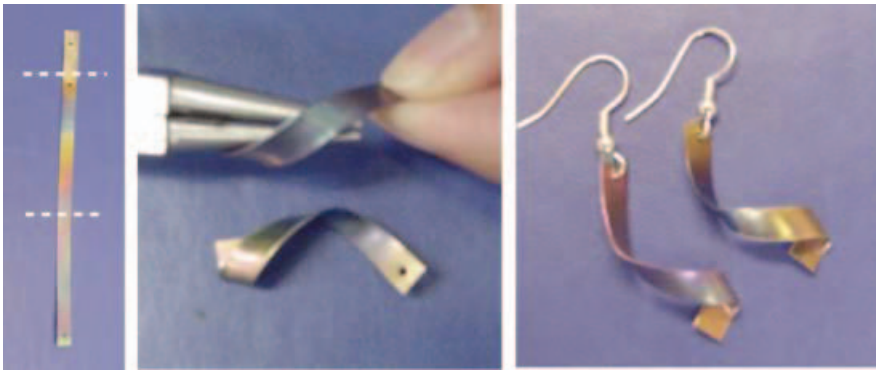

Fig. 4. *Finishing procedure.*

Groups of 20 to 30 students then proceed inside for the demonstration and jewelry distribution.

Helpful Hint: Create at least 200 earrings prior to the Open House to prepare for high demand and familiarize everyone with the process under no-stress conditions

At peak hours, this exhibit requires 10 people: 1 poster presenter, 3 demo operators, 4 earring/ring assemblers, and 2 crowd controllers.

Helpful Hint: During peak hours, you should limit the selection of earrings available for maximum throughput.

Acknowledgments

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