Electroplating Knowledge

This page explains the scientific principle behind electroplating, and offers two demos, but it does not discuss the real-world industrial situation.

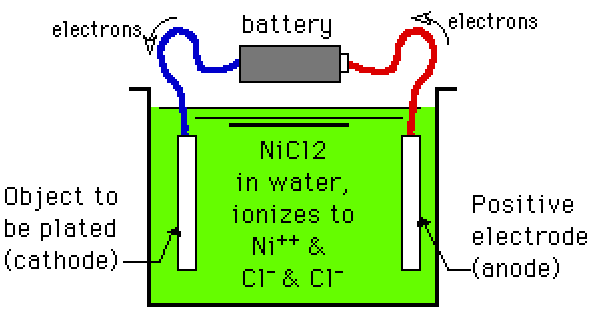
In the real world, things like polishing, pre-treatment, and post-treatments are often more critical than the electroplating step itself. In the real world, it is not often not possible to get satisfactory plated coatings without buying patented organic additives from the patent holders. In the real world, consideration must be given to safety issues, proper waste treatment and disposal, and a host of other issues. Remember, this page explains some of the basic science of the electroplating, but is NOT a guide to doing practical industrial electroplating.

What is electroplating?

Electroplating is the deposition of a metallic coating onto an object by putting a negative charge onto the object and immersing it into a solution which contains a salt of the metal to be deposited. The metallic ions of the salt carry a positive charge and are attracted to the part. When they reach it, the negatively charged part provides the electrons to reduce the positively charged ions to metallic form.

How does it work?

Look at the figure below, and then follow the written explanation.



Imagine that we have an object that is made of copper or steel, and that it has been properly cleaned, and that we now want to plate it with nickel. A wire is attached to the object, and the other end of the wire is attached to the negative pole of a battery (the wire is blue in this picture). To the positive pole of the battery we connect the red wire; the other end of the red wire we connect to a rod made of nickel.

Now we fill the cell with a solution of a salt of the metal to be plated. It is theoretically possible to use a molten salt, and in rare cases that is done, but most of the time the salt is simply dissolved in water. The $NiCl_2$ ionizes in water to Ni^{++} and two parts of Cl^-

Because the object to be plated is negatively charged, it attracts the positively charged Ni^{++}. The Ni^{++} reaches the object, and electrons flow from the object to the Ni^{++}. For each atom of Ni^{++}, 2 electrons are required to neutralize it or 'reduce' it to metallic form.

Meanwhile, the negatively charged Cl- ions are attracted to the positively charged anode. At the anode, electrons are removed from the Nickel metal, oxidizing it to the Ni^{++} state. Thus the nickel metal dissolves as Ni^{++} into the solution, supplying replacement nickel for that which has been plated out, and we retain a solution of nickel chloride in the cell.

We used nickel chloride as the first example here for a number of reasons, including simplicity. But we do not recommend that nickel be used for school science demonstrations because some people are quite allergic to it; and we do not recommend that chloride salts be used, because it is possible to release chlorine gas from them.

A demonstration

For the first demonstration, the cathode is copper (the pennies), the anode is zinc, and the electrolyte (solution) is a water based zinc salt.

One easy source of zinc is the shell of conventional carbon-zinc batteries (make sure not to use alkaline batteries like Duracell or Eveready Energizers, nor rechargeable nickel-cadmium batteries, but the cheap 1-1/2 volt AA, C, or D plain carbon-zinc batteries). One can safely cut up such batteries and remove all the black glop, and take the zinc out. An alternative is to sand down a modern U.S. penny until the copper surface is removed and the underlying zinc substrate is exposed.

For the pennies you wish to plate onto, any pennies will do, but if you start with a dull brown penny, you'll end up with a dull zinc plating. So, try to find a shiny new penny for best results. Immediately before plating, clean it with toothbrush and toothpaste, or a relatively safe scouring powder like Bon Ami or Multiscrub. Rinse well after cleaning, and use plastic gloves so you do not get fingerprints or other soils on the penny after cleaning.

A transparent plating container is best, a Pyrex beaker is fine; but if not available, a Pyrex dessert bowl can serve well. A recipe found to work is:

Fill the container about half way with vinegar, but measure how much vinegar that is. Put the zinc anode into vinegar and let it sit for several hours, allowing some of it to dissolve. We'd like to shoot for 100 g/l of dissolved zinc, although the vinegar probably will not support that much dissolution.

Add 100 g/l of Epsom Salts
and 120 g/l of table sugar.

Connect one flashlight battery (1-1/2 volts) to the penny and the zinc, and place them into the solution. Don't let them touch each other. With luck, within a few minutes you'll begin to get a bright silvery coating right out of the cell. Ted didn't have quite that much luck when he tried it, but did find that a reapplication of the toothbrush and toothpaste quickly polished the greyish coating to a bright shine.

Another demonstration

Another slightly harder demonstration is plating a quarter or a brass key with copper. The key on the left was copper plated from a solution of vinegar with a pinch of salt and a pinch of sugar, again using a 1-1/2 volt flashlight battery for power.

Remember that you can't plate a metal out of a solution until you can dissolve that metal into the solution. Copper will not dissolve in vinegar without electricity to help it along, so it's best to get started with a small piece of scrap as your cathode and a large coil of copper wire as the anode. I stripped about 2 foot of 14 gauge wire as the anode and used a 1/2 inch length of stripped copper wire as the scrap cathode. After I ran it this way for a couple of hours the solution had a faint blue tinge to it--indicating at least a little copper was dissolved in it. Then I cut off the scrap length of cathode wire, attached the key and plated it for several hours. Vinegar is too weak an acid to support a lot of copper in solution, so there is no rushing it, you have to plate slow and for a long time. I found that just a pinch of salt (maybe two shakes) was enough. If you use more, all that happens is you generate a lot of hydrogen gas and smut --you can't plate copper out of solution faster than it goes into solution.