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Using the Properties of Reactive Metals In Jewelry-Making

by Rio Grande Technical Outreach

In today's jewelry marketplace, the coloring of metals is a growing trend. Although there are a number of methods for imparting color to metal—exotic alloys, plating, patinas, e-coating—reactive metals offer one of the best, producing a brilliant—and controllable—array of colors that become part of the metal itself. Care must be taken to avoid damaging the metal surface during the fabrication of the jewelry pieces after the coloring process. Although it may fade somewhat over time, the color is long-lasting when used on pieces such as earrings and pendants and for embedded embellishments. So, what is a “reactive metal”?

Reactive vs. Stable Metals

Reactive metals are defined by their sensitivity to their environment. Because of this reactive property, these metals exist in nature as compounds, not as discrete elements, and are never found in pure form. In fact, separating them from the minerals in which they are found can be work intensive, time-consuming, and costly. The most reactive metals are found in the left two columns of the periodic table and the level of reactivity decreases from top to bottom and from left to right on the table. These metals undergo chemical reactions when combined with or exposed to other elements, such as oxygen, hydrogen and nitrogen. Potassium (K) and sodium (Na) are the most reactive element and react violently when exposed to air and water—potassium, in fact, ignites when it comes into contact with water. Titanium (Ti) burns in air and is the only element that will burn in an atmosphere of pure nitrogen (great for fireworks!). Other reactive elements include magnesium (Mg), aluminum (Al), niobium (Nb) and lithium (Li).

What Is Anodizing?

Anodizing is an “electrolytic passivation” process that uses an electrolyte solution (ion-rich solids dissolved in water) and an electrical current to trigger the chemical reaction that forms the oxides on the surface of the metal. In forming, the oxide layer leaves the metal ‘passive’ (considerably less reactive) since it now surrounds and protects the metal from other elements.

This process is known as “anodizing” because the metal being treated is the anode, or positive, of the circuit (opposite from an electroplating process, in which the work piece is the cathode, or negative, of the circuit, and an anode is added to complete the circuit). When voltage is applied to an electrolytic bath containing a positive and negative electrode, the bath conducts electricity from one to the other. The current flows from the piece being anodized, which produces oxygen at its surface, to the negative electrode, which produces hydrogen at its surface. The oxygen reacts with the metal to create oxide (AlO₂, TiO₂ or NbO₂) on the surface of the metal. A negative charge cloud forms around the cathode and a positive charge cloud forms around the reactive metal, and the layer of oxide builds up on its surface.

Throughout the process, the ions in the electrolyte attach to and neutralize the positive and negative charges, keeping the chemical reaction going for as long as the voltage can penetrate the thickening oxide layer to reach the metal surface. The percentage of electrolyte chemicals in the solution can affect the duration of the reaction; when desired, using a lower concentration of chemicals can slow the reaction.

What Good Are Oxide Layers?

After the anodizing process is complete, the transparent layer of oxide on the surface of the metal provides (or enhances) corrosion- and wear-resistance of the metal, provides a better surface for adhesives, and—and here’s the best part—interferes with and distorts the light rays that pass through the oxide layer and strike the metal surface. In niobium and titanium, the effect is reminiscent of the colors you might see on wet asphalt; the oils on the pavement coat the surface of the water, interfere with the light as it passes through the water, and create a rainbow of shimmering colors. The difference here, of course, is that the colors are controllable and will last as long as the oxide layer remains on the metal (though, over time, colors may fade a bit). The particular color produced is determined by the thickness of the oxide layer, which is in turn determined by the voltage and duration of the anodizing process.

As the oxide layer thickens, higher and higher voltage is required to reach the metal beneath the oxide and keep the reaction going. Held at a specific maximum voltage level, then, the layer will reach its maximum thickness and the process will stop. This is how you control and predict the color you achieve—a set voltage for a set period of time under the same operating conditions yields the same color, time after time.

Reactive Metals Used In Making Jewelry

Niobium and titanium, because of the effect the oxide layer has on them, are the two reactive metals most commonly used in making jewelry. These two react the most colorfully and reliably to the anodizing process.

Niobium

Thought to be named for Niobe, the daughter of Tantalus, because niobium is a close relative of the element tantalum (in fact, for a long time the two were thought to be the same element). The metal is white with a platinum-like grayish tone and has a bright metallic luster that can darken somewhat, taking on a bluish tinge when exposed to air over a period of time. Niobium is commonly used in lamp filaments, arc-welding rods, advanced airframe systems and a variety of aerospace applications. The fact that the metal is naturally hypoallergenic and contains no nickel or lead makes it ideal for jewelry pieces. Interestingly, niobium has the deepest magnetic penetration depth of any element and is used to make superconducting magnets. At cryogenic temperatures, niobium is a superconductor.

Niobium is easy to anodize, needs little preparation work, and produces a broader spectrum of color than titanium. In jewelry-making processes, niobium is easy to work with.

Titanium

Named for the Titans, the first sons of the Earth goddess, titanium crystals are found in a number of mineral deposits such as rutile and ilmenite. In its pure state, titanium is lustrous and silvery-gray. Highly corrosion-resistant, titanium is ductile, easily fabricated, and can be formed with effort. Titanium sold by Rio Grande is Grade-1, commercially pure. Like niobium, titanium is hypoallergenic and naturally lead- and nickel-free. As strong as steel but weighing 45% less than steel, titanium is an excellent jewelry metal. Fun fact: the asterism in star sapphire and star ruby is the result of the presence of titanium oxide in the mineral.

Titanium requires diligent and aggressive cleaning prior to anodizing using a metal etch and produces a color spectrum a bit less broad than does niobium. Titanium is lighter in weight than niobium and is harder. In jewelry-making processes, it can take effort to form.

Anodizing Equipment and Tools

The equipment needed for anodizing includes:

- A power source or anodizing machine with color-coded leads. Note: traditional plating rectifiers cannot product the voltage necessary to anodize these metals.
- A glass or plastic container. The container must be non-conductive and large enough to hold the work piece and cathode with plenty of space between them to ensure they do not inadvertently come into contact.
- An electrolyte, granules or solution. We recommend TSP-PF granules, which produce a non-phosphate, environmentally friendly soap; however, almost any liquid electrolyte will serve.
- A cathode to complete the electrical circuit. We recommend stainless steel with a circular shape to surround the work piece in the electrolytic bath.
- A sheet of Spark Guard mesh. Placed between the positive and negative electrodes, this mesh protects against electrical shorts while the cathode and anode (work piece) are in the bath.
- A cleaning medium such as Multi-etch cleaning granules. The pristine cleanliness of the metal to be anodized is critically important.

Other supplies that are quite useful in the anodizing process include:

- Masking sheets. These are useful for preventing anodizing in strategic areas of the jewelry piece when desired or to prevent further anodizing when the goal is to create multiple colors.
- Tape for securing masks in place.
- A brayer (hand roller). This tool is very effective for burnishing masks, ensuring thorough effective contact with the metal surface.

Safety First, Always

Always keep in mind that the anodizing process involves high voltage (up to 150 or 200 volts, depending on your particular work) and this level of electricity can be deadly if not safely handled. Also the electrolyte and cleaning solutions you use may be toxic as are the dust and fumes that result from cutting and polishing operations. Always read and follow the MSDS and other safety recommendations provided with your equipment and supplies.

Visit riogrande.com to find the equipment and supplies you need to get started anodizing titanium or niobium and take advantage of the opportunities for creating with the brilliant, glorious colors made possible by reactive metals. In today's marketplace, color is king and reactive metals are your keys to the kingdom.

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