Plated Metals and Alloys of Color

*Ralph Dixon**
Basically Nickel, Inc.
East Berlin, Pennsylvania

Design engineers are now including colored electroplated deposits in their future requirements. The trend is shifting away from bright nickel and chromium. Finishes of color are now being requested. Pigmented organic coatings really don't apply. This paper will examine alloy finishes and the benefits they offer.

Keywords: *Alloy plating, decorative finishes, color finishes*

Introduction

There is a growing demand for colors in decorative plating that started in Europe and is spreading west. The beginning of this trend started with satin nickel, appearing first in plumbing components, architectural hardware and finally automotive applications. Satin finishes were applied to interior items originally, but have moved to exterior trim and grilles.

Satin nickel

The second phase of this trend now includes various shades of satins and colors. The development of satin nickels, using emulsion-based additives was the first major change to come about. These processes use the Watts formulation with an emulsion additive that produces a micro-pitted deposit. Typical satin nickel chemistry is as follows:

Nickel metal	90 g/L (12 oz/gal)
Nickel sulfate	425 g/L (57 oz/gal)
Nickel chloride	33 g/L (4.4 oz/gal)
Boric acid	40 g/L (5.3 oz/gal)
Carrier additive	2.0%
Primary additive	2.0%
Satinizer	0.02 - 0.10%
Temperature	50 - 55°C (122 - 131°F)
pH	4.5

The resulting satin nickel deposits exhibit a pitted pattern which is quite uniform and has a pearl texture. To maintain this pattern, special agitation of the solution is required. Pneumatics or mechanical devices are used to give the proper bump or vibration. This textured deposit presents many possibilities. The as-plated deposit offers an acceptable finish, the color of platinum with a slight yellow cast. When combined with various existing topcoats, a variety of shades are possible. The uniqueness of the deposit allows the bath to have a high sheen when deposited over bright nickel, or bright acid copper. When deposited over an unpolished surface, or semi-bright nickel, the finish exhibits no sheen. What we are controlling in satin nickel is first, the sheen and second, the brightness. This feature sets up a base for a wide range of finishes, when the satin deposit is followed with a top coat.

Tin-Cobalt

Tin-cobalt is a unique bath in its own right. Deposits are similar to those obtained with decorative hexavalent chromium in color (white light blue). These deposits consist of a 78% tin and 22% cobalt intermetallic alloy, and are resistant to tarnishing and atmospheric corrosion.

Tin-cobalt deposits are now being used as replacements for hexavalent chromium in the plumbing and architectural hardware industries. This process has been used in the hand tool industries for several years.

The process may be applied both in rack and barrel applications. Current densities are very low, on the order of 0.1 A/dm^2 (1.0 A/ft^2), but covering power is outstanding. When fasteners are barrel plated with tin-cobalt, the color match with components that are hexavalent chromium plated is perfect. The bath is environmentally-friendly and contains no ammonia, fluorides or chlorides.

A typical tin-cobalt bath uses the following chemistry:

Tin	21.0 g/L (2.8 oz/gal)
Cobalt	12.0 g/L (1.6 oz/gal)
Temperature	40 - 50°C (104 - 122°F)
pH	8.0
Cathode CD	0.1 - 0.2 A/dm^2 (1.0 - 2.0 A/ft^2)
Plating time	1 - 3 min

When tin-cobalt is applied over satin nickel, the deposit has a light purplish cast, quite different from deposits obtained with hexavalent chromium. This deposit would offer the cosmetic

* *Corresponding author:*
Mr. Ralph Dixon
Basically Nickel Inc.
P.O. Box 608
East Berlin, PA 17316
Phone: (717) 292-7232
E-mail: ralphdixon@basicallynickel.com

container and plumbing industries colors never before available. Tin-cobalt chemistry may be modified to produce very stable black finishes. The black finish offers abrasion resistance, and may be used without an organic topcoat, displaying satisfactory corrosion protection.

Trivalent chromium

Trivalent chromium is no longer new. Having been introduced to the plating industry 30 years ago, it has become a perfect fit. Many improvements have been made since its introduction. Early formulations were plagued with black streaking and coverage problems. These have been overcome, especially with the introduction of iridium oxide anodes.

The color of trivalent chromium, when the bath is properly maintained, is white with a slight bluish cast, as compared to hexavalent chromium. The process is susceptible to organic contamination. As the harmful organic content increases, the deposit tends to darken, and take on a yellowish hue. Maintaining the bath in a high state of purity, with the use of carbon filtration, is paramount to its successful operation.

Trivalent chromium chemistry is usually as follows:

Trivalent Chromium	4.5 - 6.0 g/L (0.6 - 0.8 oz/gal)
Boric Acid	68.0 - 83.0 g/L (9.1 - 11.1 oz/gal)
Temperature	43 - 50°C (109 - 122°F)
pH	3.3 - 3.7
Current Density	3.0 - 5.0 A/dm^2 (30 - 50 A/ft^2)
Anodes	Iridium oxide

Deposits of trivalent chromium over bright nickel are very close in color to those of hexavalent chromium. They do tend to be somewhat darker and lack the bluish hue that has become the standard of the industry for chromium deposits. When trivalent chromium is deposited over satin nickel, the deposit takes on a steel color, quite different from hexavalent chromium. Again this difference offers a new color to work with.

Tin-nickel

The final process in our assortment of deposits of color is tin-nickel. This is a bath that has the capability of producing deposits ranging in color from light gold to black, depending on plating time. It is also an environmentally-friendly process, containing no fluorides. The as-plated deposit offers good corrosion protection without requiring an organic topcoat.

The bath chemistry for tin-nickel is as follows:

Tin	2.0 g/L (0.27 oz/gal)
Nickel	10.0 g/L (1.33 oz/gal)
pH	7.5 - 8.2
Temperature	48 - 53°C (118 - 127°F)
Agitation	Eductors
Cathode CD	0.5 - 1.5 A/dm^2 (5 - 15 A/ft^2)
Filtration	Continuous
Plating Time	1 - 3 min
Anodes	Carbon

Tin-nickel produces deep dark deposits when plated for times longer than one minute. The deposit may be applied over any metallic surface in both rack and barrel applications. When deposit times are shorter than one minute, the color ranges from light gold on bright substrates, to bronze on satin substrates. The deposit may be used without an organic topcoat, offering good resistance to corrosion and tarnishing. The deposit is soft enough that it may be relieved, producing an array of antique finishes, depending on the substrate.

When additional abrasive and corrosion protection is required, tin-nickel may be plated with trivalent chromium. The deposit remains black, while acquiring the protection of trivalent chromium.

Color variations

The following list summarizes that colors and textures that can be obtained by using the various combinations of plated coatings that I have outlined.

Satin nickel	Silvery tin
Satin nickel + Hexavalent chromium	Satin blue
Satin nickel + Tin-cobalt	Purplish hue
Satin nickel + Trivalent chromium	Smokey dark
Satin nickel + Tin-nickel (10 sec)	Bronze
Satin nickel + Tin-nickel (1 min.)	Black
Bright nickel + Satin nickel	Smoky silver
Bright nickel + Tin-cobalt	Light blue
Bright nickel + Tin-nickel	Bright black
Bright nickel + Tin-nickel (10 sec)	Gold
Bright nickel + Trivalent chromium	Clear white

Final thoughts: Not new, but different

I have been working with technology from Israel that is quite unique when it comes to nickel coloring. Based on light refraction, and going by the name, "Nickel Rainbow," the process consists of chemistry that has the ability to produce any color under the rainbow over bright nickel, by varying time, temperature and current density.

Summary

I have discussed some of the possible combinations of color finishes that may be acquired with today's alloy plating baths. As designers require more color in their creations, the demand for these and other alloy deposits will increase.

About the author

Ralph Dixon has been serving the metal finishing industry for the past 50 years in all phases, from technical field service to sales management with world class suppliers. He specializes in decorative nickel and chromium finishes to the appliance, automotive and motorcycle industries. He is currently involved as a consultant in the promotion of decorative plating processes in the United States, and South America with Basically Nickel Inc.