Cobalt's Role In Passivation

Q. As an applicator, I am hearing a lot about the development of cobalt-free technology in trivalent passivates, but I would like to understand what role cobalt plays in passivation and how that will be addressed with its removal.

A. It is true that the volatility in the cobalt supply chain, coupled with potential regulatory changes, have spurred the discussion and development of cobalt-free passivates for zinc and zinc alloys. After years of successful surface finishing with trivalent passivates that contain cobalt, it is valid for applicators to want to understand the mechanism of cobalt within the chemistry and how passivates will function in its absence. To help facilitate this understanding, I have broken down the information into the following main ideas.

Cobalt's use in passivation: The addition of cobalt to trivalent chromium passivates serves to enhance the corrosion protection of the passivate film. Other transition metals, including nickel, titanium, zirconium, etc., can also accomplish this. Cobalt has become ever-present within the industry because it offers a relatively inexpensive, widely stable, and highly effective means of enhancing the corrosion resistance of passivate films.

The function of cobalt within a trivalent passivate: Cobalt plays several key roles within a trivalent chromium-based passivate. It significantly increases the corrosion resistance of the formed passivate film and serves to decrease the surface roughness of the developed passivate film. This helps to enhance its appearance. The lower the surface roughness, the more luster the final part will have. Recent research has shown that cobalt enhances the rate of nitrate reduction during the growth of passivate films. This serves to increase the rate at which chromium precipitates, which often leads to higher coating weights. The addition of cobalt also maintains the coatings' integrity following heat treatment. After annealing, passivate films decrease in thickness because of dehydration. The incorporation of cobalt maintains the passivates' thickness compared to films where cobalt is absent. Last, the number of micropores within the passivate film is also lower with cobalt than without. This decreases the number of pathways for corrosive agents.

The reasons cobalt is being removed from passivates: There are a variety of factors that influence this movement. In addition to its overall health and safety risks, replacement of cobalt is being prioritized because this compound has had a tenuous position relative to ECHA (European Chemicals Agency), REACH (Registration, Evaluation, Authorization and Restriction of Chemicals), and global responsible sourcing concerns. Another important factor is the volatility of cobalt. The limited supply and variable cost of this transition metal have become a key focal point within the past 5-10 years. The increased use of cobalt in lithium-ion batteries in electric vehicles and electronic components positions the forecast of its usage to double over the next few years to meet market demand. All these factors influence the need to determine a suitable alternative for cobalt in trivalent passivates.

Cobalt's alternative: From a product research and development standpoint, it can be difficult to find a replacement for cobalt that offers equivalent performance and is cost-effective. Nevertheless, newer technology has been developed that offers an alternative that combines nanoparticles and other transition metals to provide ample corrosion resistance and yield an aesthetically pleasing film over zinc and zinc alloys. Furthermore, these newly developed passivates have the benefit of generating a more thermally resistant film that resists degradation during hydrogen de-embrittlement baking. Last, they offer some level of self-healing capabilities. It should be noted that the elements that comprise this newer generation of passivates are more environmentally sustainable than previous versions.

Cobalt-free technology: One of the challenging aspects of the development of cobalt-free alternatives for the passivation of zinc and zinc alloys is the determination of nanoparticles that provide the necessary corrosion protection, but also remain stable within the passivate solution. The previous generation of nanoparticle- incorporated systems can suffer from the drawback of solution instability as the bath ages. Some of the newer cobalt-free technology passivates on the market have successfully overcome this challenge. They can also operate at a higher pH to limit the generation of metal contaminants, which extends the longevity of the passivate solution. In addition, certain newer technology cobalt-free black passivates for zinc-nickel can offer less aggressive active agents, which preserves the coating thickness and alloy composition, helping platers reduce cost and eliminate the need for overplating. If you are running torque-tension modifiers with your passivates, ask your chemistry supplier to ensure you are using topcoats specifically designed to work with cobalt-free passivates.

CHRISTIAN KISSIG
Columbia Chemical

Christian Kissig is a research chemist at Columbia Chemical.
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