Aluminum Pretreatment: Quo Vadis?

In the pretreatment of aluminum, we distinguish between pretreatment lines with pure aluminum throughput, mixed throughput or parts in mixed design. This also decides which chemical pretreatment method is used.

When considering aluminum as a material, we generally associate it with low weight, gloss, and a certain degree of exclusivity. These are some of the reasons why aluminum was used early on for the construction of airplanes. This was soon followed by vehicle construction, such as the body of the Land Rover prototype 1947, which was made from duralumin, an aluminum alloy developed in 1909 by Dürener Metallwerke. Components in machines, electrical cables, pipes, cans, and household items are also often made of aluminum. Worldwide, the rate at which aluminum is recycled (secondary aluminum) is about 40%.

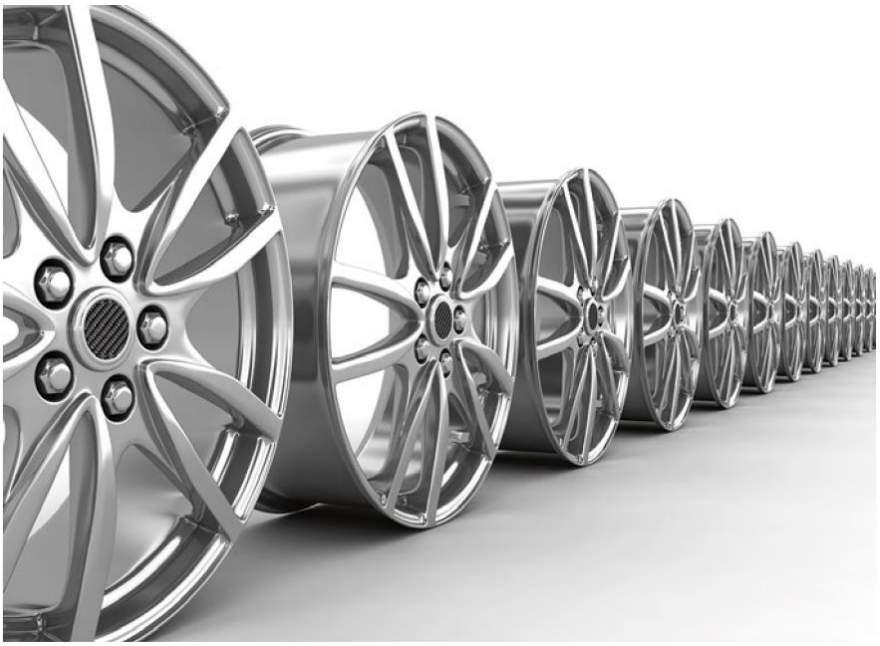
So we know that aluminum is used in many different industries: In addition to cold-rolled sheet metal, for example for soda cans or car body parts, piece castings are used for windshield wiper housings and extruded parts for aluminum window frames, among other things. Almost all of these applications need surface treatment in the form of machining/cutting, chipless cold forming, intermediate cleaning, or chemical pretreatment.

Chromium (VI) alternatives wanted

Chemical pretreatments are used prior to coating with powder paint, wet paint, or electrocoating, for example. A distinction is made between pretreatment lines that process aluminum only, such as aluminum profile coatings, and pretreatment lines with mixed throughput or parts in mixed design. With a mixed throughput, the parts are sorted by type, e.g., aluminum, steel, or galvanized steel, but they are still arranged next to each other on the goods carrier. With the mixed design, a component consists of multiple metals, e.g., in automobile bodies or supplier parts. For the chemical pretreatment of pure aluminum, yellow and green chromating processes based on hexavalent chromium were the standard until the mid-1980s. But due to the carcinogenic effect of chromates on humans, these chemicals have become a point of discussion, much like the treatment of chromate-containing wastewater and sludge. That is why the development departments of chemical surface technology companies are increasingly looking into alternative processes. Initial knowledge has already been gained in the production of aluminum cans, where chromium-free systems on the basis of hexafluoro-titanate as a conversion treatment are used.

But the obstacles are still major: Yellow chromating in particular, which has been used for decades, has set a level of quality that has yet to be matched. A unique aspect is the so-called 'self-healing function', in which – when corrosive electrolytes are introduced – chromium (VI) ions are released from the chromated and coated part surface in case of damage, thus forming a blank corrosion protection layer on in the damaged area. This effect is the main reason for the high degree of effectiveness of chromating processes: Two different courses of development were taken: On the one hand, replacing hexavalent chromium with trivalent chromium, and option two being

Aluminum is used in many industrial areas, for example to create an aesthetic building structure.



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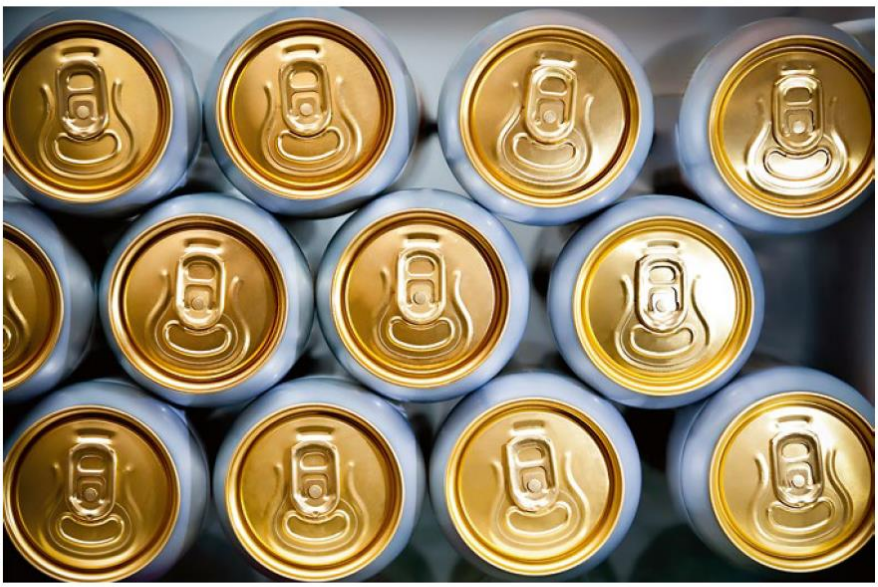
Aluminum is a popular material in vehicle construction due to its low weight and high level of gloss. Aluminum rims, for example, give cars a more expensive and sporty look.



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Chromium-free systems based on hexafluoro-titanate are already used as a conversion treatment in the production of aluminum soda cans.

the direct transition to chromium-free systems.

Addition of film formers required

Chromium (III) processes do not contain hexavalent chromium, neither in the treatment baths nor in the conversion layers produced, which means that they fully meet the chromate-free requirement in this regard. But the chromium (III) compounds contained in the formulations are often produced through the chemical reduction from starter materials that contain chromium(VI), so that chromate is still present in the production chain at this stage. In contrast, chromium-free processes are based on complex fluorides of transition metals, the most common of which are zirconium and titanium. Unlike the chromating process, neither one of these processes have a pronounced "self-healing function." In order to achieve a similar effect, chemical surface technology adds film formers, which give the metals that are built into the conversion layer an embedding matrix that thickens the protective layer.

With the transition to chromate-free processes, quality associations like GSB and QualiCoat have also become established. These associations are tasked with defining, verifying, and certifying the pretreatment and coating processes. Both users and suppliers of pretreatment and coating systems are affected.

The following article examines the individual steps of chemical pretreatment and points out some phenomenological facts:

Cleaning and pickling

With alkaline cleaning, aluminum is partially pickled at pH values above 11, which can discolor the surface. Silicates and borates have an inhibiting effect at higher pH values. Kluthe recommends Hakupur 10-636 as the standard cleaning system and Hakupur 10-920 for alkaline pickling.

In order to achieve a sufficiently high pickling action, systems that contain fluoride are used. In some cases, surfactants can be added to the sulfuric acid-fluoride mixtures to improve surface wetting. Such mixtures also serve as acidic cleaners or pickling cleaners. Kluthe recommends the Decorrdal AL 20-16-1 cleaner.

Conversion treatment based on substrate mix

In the pretreatment of pure aluminum, chromating processes are now being replaced by processes based on titanium or zirconium formulations, which are also used in pickling passivation. A distinction is made between rinse and no-rinse processes. No-rinse processes do not use a rinsing cycle after the conversion treatment, which is why the formulations must be coordinated in such a way that the pretreatment chemistry reacts completely without leaving any residue and only a little residual electrolyte remains on the aluminum surface. Kluthe offers Decorrdal Al 230 A for the rinse process and Decorrdal Al 240 A for the no-rinse process.

In chemical pretreatment, a distinction is made between pretreatment lines that process only aluminum, mixed throughput, or mixed-design parts.

Processes containing chromium (III) are also used alongside chromium-free processes. The formulations often contain transition metal compounds that are incorporated into the conversion layer. Kluthe developed the Decorrdal AL 325 pretreatment system for this.

Throughput of different substrates on a product carrier and mixed design

When different substrates such as steel, cast iron, galvanized steel, and aluminum have to be pretreated simultaneously on a product carrier, the pretreatment processes must be coordinated. The processes designed for treating aluminum only usually no longer work properly here. Processes that form a conversion layer or, at a minimum, a passive layer on aluminum are used, as well as processes that only slightly pickle or matte.
For chrome-free treatment, the processes are essentially based on titanium and zirconium salts or mixtures thereof, e.g. Decorrdal 935. Normal-temperature and low-temperature zinc phosphating coatings are also used primarily in connection with KTL in the vehicle industry, which can be set either to layer-forming or non-layer-forming for aluminum, e.g. the Decorrdal 330 LT series.
Iron phosphating systems, such as Decorrdal 40-28-4 SAZ or Cleaner Coater (Decorrdal 921) are also used in conjunction with powder coatings for less stringent requirements.
For less demanding applications, there are also special washing processes, which at most produce a slight staining or matting of the surface:

- Neutral cleaner, for example Hakupur 10-445
- Alkaline cleaners, for example Hakupur 10-636 (caution: Aluminum is amphoteric and also dissolves in alkali, which can lead to discoloration in aluminum alloys).
- Iron phosphating systems
- Cleaner coater systems

The various pretreatment systems at Chemische Werke Kluthe can therefore be used in all aluminum refinement stages and range from non-cutting and metal-cutting processing to coating pretreatment to achieving blank corrosion protection. //

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