



# **CHEMICAL CONVERSION TECHNOLOGY OF ALUMINUM**

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**Aluminum Chemical Conversion: Electroless Coating—Turning Aluminum into a Corrosion-Resistant Superhero?**

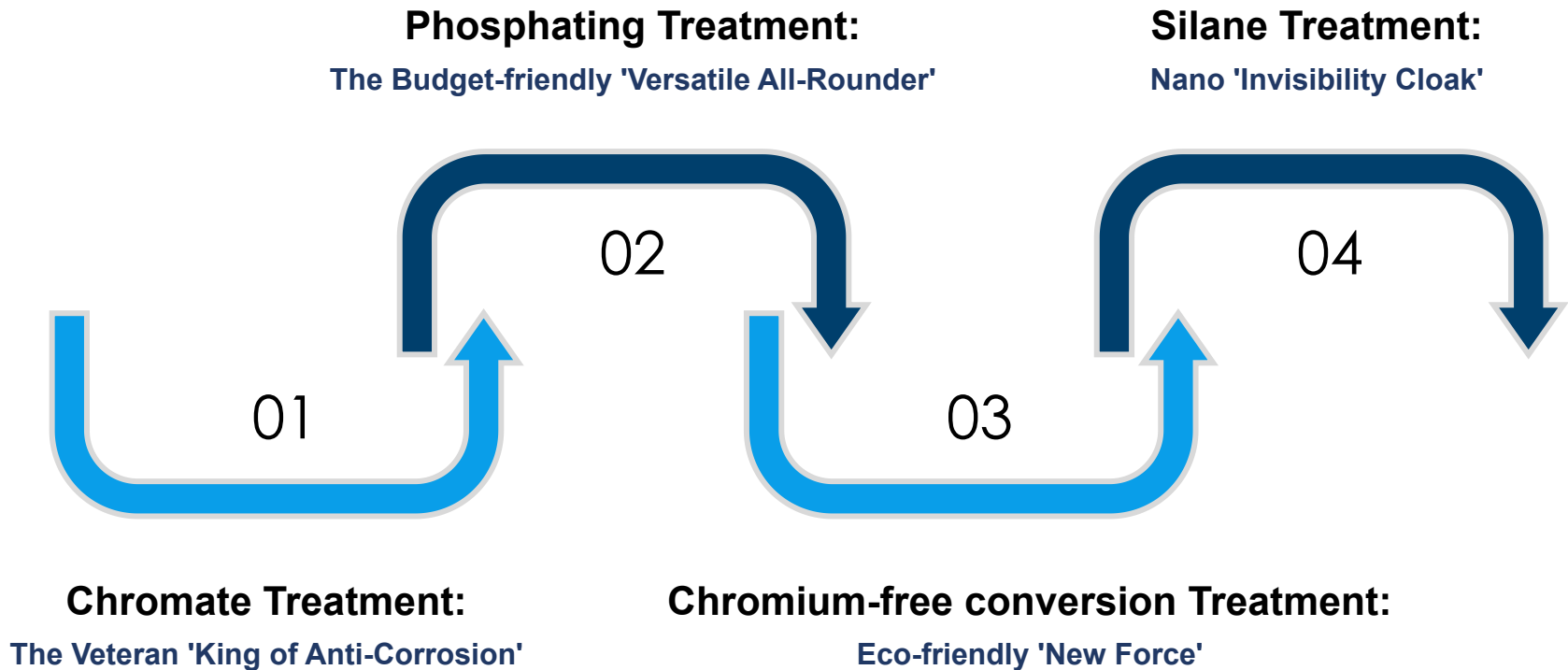
# What is Chemical

## Conversion Technology ?



Chemical conversion technology involves immersion or spraying chemical solutions to cause reactions on the surface of aluminum, resulting in the formation of a dense non-metallic conversion film. Unlike anodizing (which requires electricity), it has a simple process, low energy consumption, and is suitable for high-volume production.

# Analysis of the Four Mainstream Technologies



# 01 Chromate Treatment: The Veteran 'King of Anti-Corrosion'

**Principle:** Immerse aluminum in an acidic solution containing hexavalent chromium ( $\text{Cr}^{6+}$ ) to form a chromate alumina-composite film.



## Advantages:

- Extremely strong corrosion resistance (neutral salt spray test for 1000+hours).
- Self healing ability: The film layer can self repair after minor scratches.
- Enhance coating adhesion (widely used as a spray coating substrate).

## Disadvantages:

- Hexavalent chromium is toxic and requires strict wastewater treatment (EU RoHS has restricted its use).

## Application:

- Aviation fasteners, military equipment.
- Traditional architectural aluminum profiles (gradually being replaced).

# Phosphating Treatment:

## The Budget-friendly 'Versatile All-Rounder'

**Principle:** Phosphate solution reacts with aluminum to form porous aluminum phosphate film



### Advantages:

- Low cost, fast film formation (1-5 minutes).
- Improve lubricity, suitable for subsequent stamping or drawing.
- Environmental friendliness is better than chromate.

### Disadvantages:

- Corrosion resistance is weak (salt spray test < 200 hours), and needs to be combined with sealing agent.

### Application:

- Automobile engine covers, radiators.
- Aluminum hardware components (screws, gaskets).

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# Chromium-free conversion Treatment:

## Eco-friendly 'New Force'

**Principle:** Replace chromium with titanium/zirconium salts, rare earths, or organosilicon to form a nanoscale conversion film.



### Advantages:

- Completely chromium-free, compliant with RoHS and REACH regulations.
- Wastewater treatment is simple and environmentally friendly.
- Customizable colors (such as blue, gold).

### Disadvantages:

- The corrosion resistance is slightly inferior to chromate (salt spray test for 500-800 hours).

### Application:

- Consumer electronics products (phone frames, laptop shells).
- Food packaging aluminum cans (e.g. inner wall of cola cans).

## Silane Treatment: Nano 'Invisibility Cloak'

**Principle:** Silane coupling agents react with hydroxyl groups on the surface of aluminum to form ultra-thin organic-inorganic hybrid films.



### Advantages:

- The film thickness is only at the nanoscale (0.1-1 $\mu$ m), which does not affect the size.
- Enhance the adhesion with organic coatings (paints, adhesives)
- Environmentally friendly and non-toxic, suitable for medical and food applications.

### Disadvantages:

- The corrosion resistance is limited when used alone, and is mostly used as a pre-treatment for coating.

### Application:

- Automotive body aluminum plate (Tesla integrated die-casting).
- Medical devices (surgical forceps, stents).

# Technical Comparison:

## How to Avoid Pitfalls in Selection?

Technology	Corrosion Resistance	Environmental Performance	Cost	Application
Chromating	★★★★★	★	Medium-priced	Military industry, aerospace industry
Phosphating Treatment	★★	★★★	Low price	Hardware components, auto parts
Chromium-free Conversion Treatment	★★★★★	★★★★★	Medium-high price	Food packaging, 3C electronics
Silane Treatment	★★	★★★★★	High price	High-end coating, medical equipment

# Industry Pain Points and Solutions

## Environmental compliance challenges

**Challenge:** Hexavalent chromium is banned globally, and traditional processes are facing elimination.

**Solution:** Switch to chromium-free conversion films (e.g., zirconium titanium systems), or develop bio-based converting agents (e.g., phytic acid extracts).

## Layer uniformity

**Challenge:** Uneven film-formation in the grooves of complex workpieces.

**Solution:** Ultrasonic-assisted treatment, or the use of nano-scale film-formers agents to improve coverage.

## Compatibility of coatings

**Challenge:** The conversion film does not match the subsequent spraying and adhesive processes.

**Solution:** Customized pre-treatment solution (such as silane+electrophoretic paint "golden combination").



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01

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## Conclusion

From highly toxic chromates to green zirconium titanium films, from thick phosphating layers to nanoscale silane "invisibility coat", chemical conversion technology has embarked on an evolutionary path in environmentally friendly and high-performance steel wires.

It makes our coke safer, our mobile phones more durable, and the electric cars we drive lighter - this invisible film is the gentle protection of technology for daily life.