

# Chengdu Hanhao Lixin New Materials Technology Co., Ltd.

## High-Temperature Anti-Oxidation Coating for Prebaked Anodes in Aluminum Electrolysis

### Company Profile

The company is driven by advanced technology and works in collaboration with relevant colleges and universities to develop and apply a wide range of energy-saving products. Its main products include superhard wear-resistant coatings, carbon anti-oxidation coatings for aluminum electrolysis, and various high-temperature anti-oxidation coatings. Adhering to the principles of quality first and integrity-based operation, the company is committed to providing customers with high-quality products and services.



The carbon anti-oxidation coating for aluminum electrolysis is manufactured using a core technology in which micron-scale ceramic powders are modified with a polymer-based metallic binder. The product can cure at ambient temperature within 12 to 24 hours. It is easy to apply and features strong adhesion, excellent penetration, and good film-forming properties. This non-toxic inorganic coating is suitable for

high-temperature smelting applications involving graphite electrodes and carbon materials used in aluminum electrolysis. Pre-sintering can be completed at 300°C to 500°C, and the coating can withstand prolonged exposure to temperatures above 900°C, while resisting attack from high concentrations of carbon dioxide, hydrogen fluoride, and oxygen. It effectively isolates conductive graphite and carbon materials from high-temperature oxidation. After 24 hours of calcination in air at 900°C, the weight loss rate is approximately 3%.

### Comparative Test of Anode Oxidation

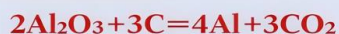


## Technical Overview

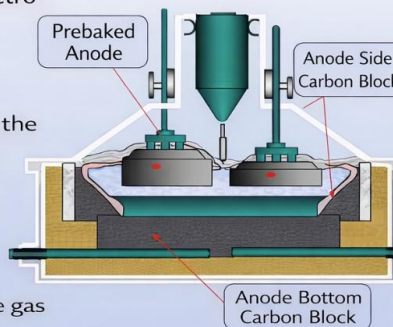
### (I) Schematic Illustration

#### 1 Prebaked Anode Consumption in Aluminum Electrolysis

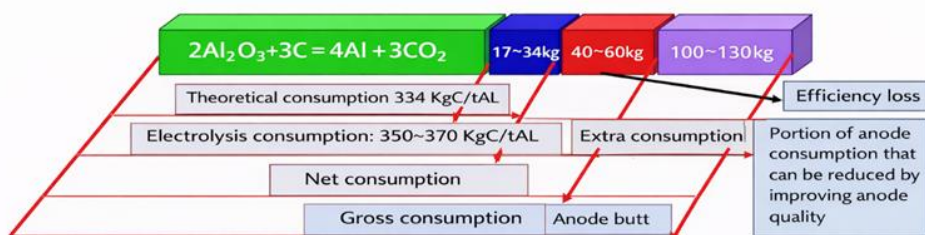
In the Hall-Héroult process of aluminum electrolysis, carbon materials are used as the anode, playing a dual role of conducting electricity and participating in electro-chemical reactions:



- ◆ The quality of anode carbon blocks directly impacts the normal production operations, the quality of primary aluminum, and current efficiency, as well as other economic and technical indicators;
- ◆ The anode accounts for approximately 13% of the aluminum electrolysis production cost;
- ◆ Carbon anodes produce a large amount of greenhouse gas ( $\text{CO}_2$ ) during the aluminum electrolysis process.



#### 2. Breakdown of Anode Consumption

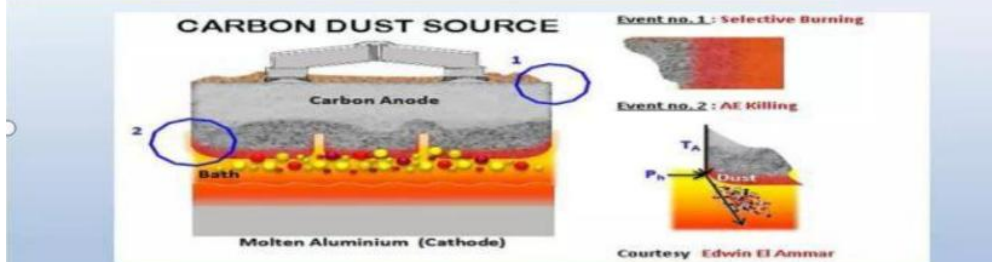


- Extra consumption:
- ◆ Air oxidation  $\text{C} + \text{O}_2 = \text{CO}_2$   $2\text{C} + \text{O}_2 = 2\text{CO}$
  - ◆  $\text{CO}_2$  oxidation  $\text{C} + \text{CO}_2 = 2\text{CO}$
  - ◆ Mechanical spalling:
    - Selective oxidation of binder pitch;
    - coke particle detachment

Overseas: 0.80–0.95A/cm<sup>2</sup>, Net 390–420kg/t·Al;

China: 0.72–0.80A/cm<sup>2</sup>, Net 400–420kg/t·Al.

#### 3 Mechanism of Extra Anode Consumption



## **(II) Extension of Prebaked Anode Service Life Through Anti-Oxidation Protection**

The high-temperature anti-oxidation coating for prebaked anodes in aluminum electrolysis is applied by spraying to form a ceramic protective film on the side surface of the anode carbon block. This protective film prevents attack by air, CO<sub>2</sub>, and electrolyte vapors, thereby reducing oxidation and spalling on the carbon-block surface. Under the condition that the line current remains unchanged, the effective conductive area at the bottom of the anode carbon block correspondingly increases. As a result, the daily height loss of the anode carbon block is reduced. Over one operating cycle, the reduction in anode height loss is roughly equivalent to about one extra day of service life. In this way, carbon consumption in aluminum electrolysis can be reduced by 13–15 kg, without causing any adverse effects on the aluminum electrolysis system.

## **(III) Characteristics of the Coating Material**

1. Resistant to high-temperature fluoride-containing vapors;
2. Has a thermal expansion coefficient close to that of carbon materials, making it less prone to spalling and cracking;
3. Reduces the reaction between carbon materials and air at high temperatures, thereby reducing surface burning of the carbon block;
4. Can be sintered into a protective film at relatively low temperatures;
5. Has been verified over a long period to have no effect on the electrolyte system;
6. An inorganic water-based coating that is harmless to both humans and the environment.

## (IV) Laboratory Testing of the Coating Material

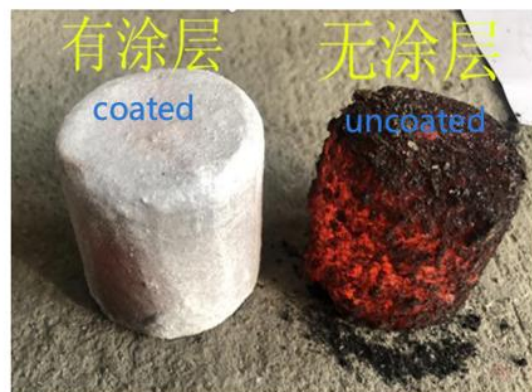


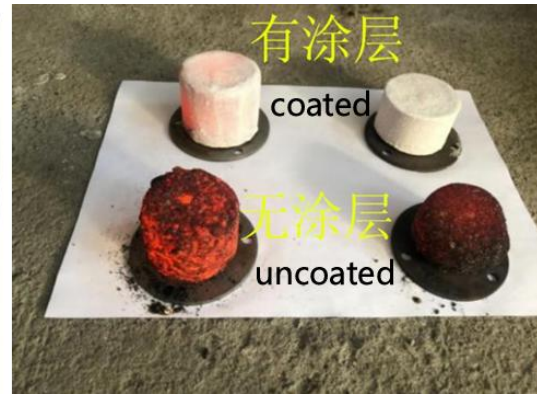
### 1. Comparative Test of Segmented Oxidation



### 2. Air Calcination Test

Comparison of 48-Hour Air Calcination at 900°C with and without Coating





### 3. Use of Coated Anodes in the Electrolytic Cell



Anti-oxidation protection during preheating of start-up cells

The large face adjacent to the neighboring anode remained unoxidized after 240 hours.

### (V) Industrial Application Performance of the Coating Material

#### 1. Application to Anti-Oxidation Protection of Prebaked Anodes in Aluminum Electrolysis

1) Qualitative Comparative Test: In a set of twin anodes, one carbon block was coated with the coating material, while the other was left uncoated. After installation in the

electrolytic cell, the large face was left untrimmed and exposed to the environment in order to observe the anti-oxidation performance.



Conclusion: Under the same oxidation conditions, oxidation of the carbon block coated with the coating material proceeds very slowly.

## 2. Comparison Between Coated and Uncoated Anodes



Verification through large-scale application of coated anodes in an aluminum electrolysis plant showed that the anode butt thickness increased by 10–16 mm, and the anode change cycle was successfully extended by 1 day.

### 3. Anode Spraying



### 4. Conveyor Transport of Sprayed Anodes



### 5. Anode Transfer



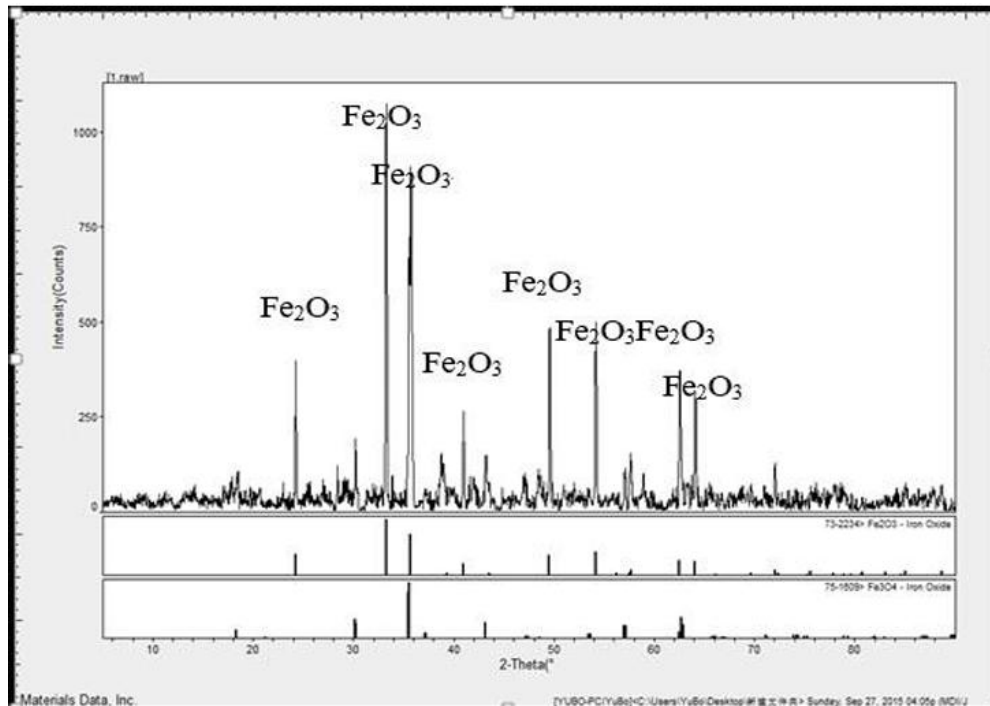
## Anti-Oxidation Coating for Steel Stubs



Area of Severe Oxidation on the Steel Stub



Significant Reduction in Steel Stub Diameter



The oxidation products on the steel stub are a mixture of Fe<sub>2</sub>O<sub>3</sub> and Fe<sub>3</sub>O<sub>4</sub>, and the characteristic peak intensity of Fe<sub>2</sub>O<sub>3</sub> is much higher than that of Fe<sub>3</sub>O<sub>4</sub>. Therefore, the oxidation products are a mixed phase predominantly composed of Fe<sub>2</sub>O<sub>3</sub>. Since Fe<sub>2</sub>O<sub>3</sub> is the principal component of rust and is non-magnetic, magnetic separation used for iron removal from returned material can remove only part of the Fe-containing compounds.



After the coating was knocked off, the steel surface retained its original metallic appearance, and no signs of oxidation were observed. By contrast, the uncoated side had undergone severe oxidation, with an oxidation depth of 1 mm and a dull surface appearance. Test results demonstrate that the steel stub anti-oxidation coating can reduce oxidation and corrosion of the steel stub by approximately 60%, while doubling its service life. In addition, oxidation of the steel stub can cause the iron content in molten aluminum to increase by 1000 ppm. Magnetic separation for iron removal can reduce this increase to 600 ppm, whereas the steel stub anti-oxidation coating can limit the increase in iron content to about 300 ppm even without magnetic separation. That is:  $1000 \text{ ppm} \times (1 - 70\%) = 300 \text{ ppm}$ .

### Steel Stub Coating



## **(VI) Conclusions of the Industrial Trial on Anode Anti-Oxidation**

1. Over a complete electrolysis cycle, the coating remained well adhered to the outer surface of the anode carbon block, reducing oxidation and spalling on the side surface of the anode, thereby extending the service life of the anode. The anode butt also retained a squarer and more regular shape.
2. The elements introduced by Hanhao Lixin carbon anti-oxidation coating for aluminum electrolysis had no adverse effects on the quality of primary aluminum or on the electrolyte system.

## **(VII) Benefit Analysis of the Anode Anti-Oxidation Project for a 300,000-tpy Aluminum Electrolysis Plant**

1. By extending the anode change cycle by 1.0 day, the theoretical reduction in carbon consumption per tonne of aluminum can reach 14.2 kg.

(1) Benefit from reduced carbon consumption: Based on an annual average carbon price of RMB 3.3/kg, a 300,000-tpy aluminum electrolysis plant can achieve annual savings from reduced carbon consumption of:  $30 \times 14.2 \times 3.3 = \text{RMB } 14.05 \text{ million}$

(2) Coating application cost: The coating cost per tonne of aluminum is RMB 24, labor cost is RMB 1, and equipment cost is RMB 1, giving a total application cost of RMB 26 per tonne of aluminum. Therefore, the annual coating application cost for a 300,000-tpy aluminum electrolysis plant is:  $30 \times 26 = \text{RMB } 7.8 \text{ million}$

(3) Direct annual economic benefit from reduced carbon consumption:  $14.05 - 7.8 = \text{RMB } 6.25 \text{ million}$

Practice has demonstrated that Hanhao Lixin carbon anti-oxidation coating for aluminum electrolysis represents one of the most advanced technologies currently available for anti-oxidation protection of anodes and steel stubs in aluminum electrolysis. It can be widely applied in aluminum electrolysis and other metallurgical production lines, where it plays a highly important role in anti-oxidation protection,

reducing anode consumption, lowering labor intensity, and improving economic performance.

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