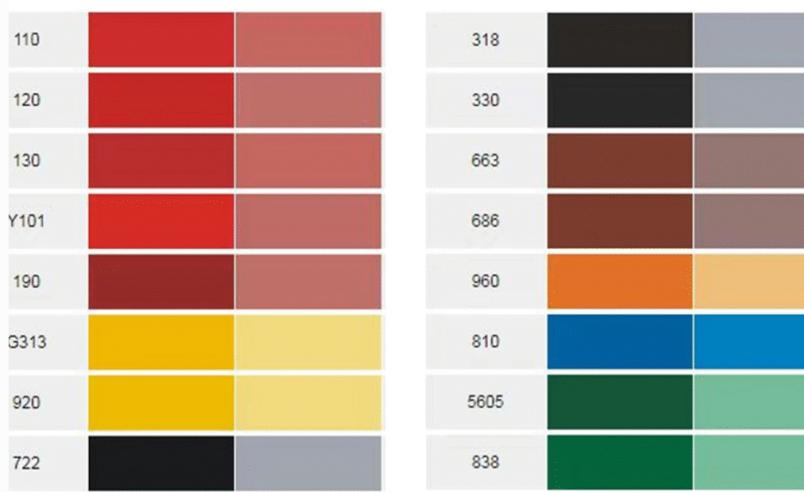


# Iron Oxide Pigment: Manufacturing, Applications, and Color Control



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Iron oxide pigments are widely used inorganic colorants known for their durability, non-toxicity, and rich range of hues. Produced through either dry (thermal) or wet (precipitation) methods, these pigments appear in applications from construction and coatings to plastics and asphalt. This article explores how production processes influence color formation, how particle size affects hue brightness or depth, and how different color indexes like R110 or R180 are defined. Whether in vivid reds or earthy yellows, iron oxide pigments offer versatile and stable performance across industries.



Iron oxide pigments are widely used inorganic pigments known for their non-toxic nature, excellent chemical stability, and vibrant, durable colors. Its application is the second inorganic pigment in nature, only less than [titanium dioxide](#). This article provides a comprehensive look at how iron oxide pigments are produced, how different color shades are formed and controlled, their applications, and the key indicators found in quality certificates.

## 1. How Iron Oxide Pigments Are Produced: Dry vs. Wet Process

[Iron oxide pigments](#) are primarily manufactured through two processes: the **dry process** and the **wet process**. Both routes yield pigments with different properties tailored for specific applications.

### Dry Process (Thermal Decomposition Method)

In the dry process, iron salts (often iron sulfate or iron nitrate) or scrap iron is calcined at high temperatures (300–1000°C). The heating leads to oxidation and crystallization, forming iron oxides:

- **Iron(III) oxide ( $Fe_2O_3$ )** for red shades
- **Iron(II,III) oxide ( $Fe_3O_4$ )** for black shades

This process is ideal for producing deep red or black pigments, especially for **construction** or **coating** applications.

### Wet Process (Precipitation and Oxidation)

The wet process involves a series of aqueous chemical reactions. A typical example (for red iron oxide) involves:

1. **Dissolving Ferrous Sulfate ( $FeSO_4$ )** in water to form a  $Fe^{2+}$  solution.
2. **Adding alkali (e.g.,  $NaOH$  or lime milk)** to form a greenish precipitate of  $Fe(OH)_2$ .
3. **Oxidizing** this with air to form  $Fe(OH)_3$ .
4. **Controlled heating (50–100°C)** promotes hydrolysis and crystallization into  $Fe_2O_3$ .
5. The pigment is then **filtered, washed, dried, and milled** into fine powder.

Wet processes allow better **color control** and **fine-tuning of particle size and shape**, making them more suitable for **high-value applications** like coatings and plastics.

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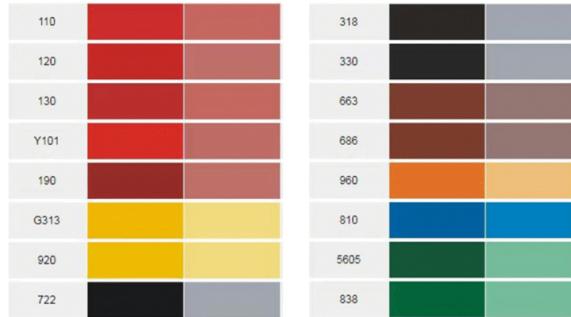


## 2. Applications of Iron Oxide Pigments

Iron oxide pigments are versatile and used across a range of industries:

Industry	Application
Construction	Concrete bricks, pavers, roof tiles, colored cement
Coatings & Paints	Anti-corrosive primers, architectural paints, industrial coatings
Plastics	Masterbatches, PVC, PP, PE coloring
Rubber	Tire coloration, synthetic rubber fillers
Asphalt & Bitumen	Colored asphalt and decorative pavement

## 3. How Hue Is Controlled in Wet-Processed Iron Oxide Pigments



The hue spectrum of iron oxide pigment diagram

In the wet process, the **color tone (hue)** of the iron oxide pigment is influenced by:

### Reaction Temperature

Higher temperatures promote crystallization and dehydration:

- 50–70°C → Yellow shades (FeOOH)
- 80–100°C → Orange to red hues (Fe<sub>2</sub>O<sub>3</sub>)
- 100°C (or dry calcination) → Deep red to purple-red

### Oxidation Time and Conditions

Longer oxidation times allow fuller conversion of Fe<sup>2+</sup> to Fe<sup>3+</sup>, leading to darker tones.

### Crystal Growth and Particle Size

Smaller particles reflect more light → brighter tones (e.g., R110) Larger particles absorb more light → deeper/duller tones (e.g., R180)

### Relationship Between Hue and Fineness (Particle Size)

In addition to reaction temperature, oxidation rate, and pH control, the **particle size (fineness)** of iron oxide pigments is a critical **physical factor** influencing the final hue. Particle size affects the pigment's ability to scatter or absorb light, thereby altering its optical appearance.

Particle Size (µm)	Optical Behavior	Hue Appearance
< 0.3 µm	Enhanced light scattering	Brighter tones like vivid red or yellow
0.3–0.5 µm	Stable optical behavior	Standard red or yellow
> 0.5 µm	Enhanced light absorption	Darker tones like maroon, brown, or purplish-red

- **Smaller particles** → Stronger light reflection → **Brighter and more yellowish tones**
- **Larger particles** → Stronger light absorption → **Darker and more brownish/purplish tones**

For example:

- In iron oxide red pigments, finer grades such as R110 tend to appear more vivid and brighter.
- Coarser grades like R180 or R190 appear darker and more muted.

Thus, **fineness control during grinding and classification** allows manufacturers to adjust hue within the same color family. It works in tandem with chemical parameters to achieve precise color tuning and consistent product quality.

Conclusion: The hue is not just controlled by temperature, but by a complex interplay of **reaction conditions**, crystallinity, and particle morphology.

## 4. How Different Color Shades Are Formed: Red, Yellow, Black, Green, Blue

Color	Chemical Form	Production Method
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Red (Fe <sub>2</sub> O <sub>3</sub> )	Iron(III) oxide	Wet or dry oxidation of Fe <sup>2+</sup> salts
Yellow (FeOOH)	Goethite ( $\alpha$ -FeOOH)	Controlled oxidation of Fe <sup>2+</sup> at 50–70°C
Black (Fe <sub>3</sub> O <sub>4</sub> )	Magnetite (Fe <sup>2+</sup> + Fe <sup>3+</sup> oxide)	Partial oxidation of Fe <sup>2+</sup> or thermal decomposition
Green	Chromium-iron mixed oxides	Solid-state reactions at high temperatures (non-iron source)
Blue	Complex mixed oxides	Often iron-cobalt-alumina systems formed via solid reaction

Note: Iron oxide green/blue pigments are often **not pure iron oxides** but include other transition metal oxides.

## 5. What Do the Iron Oxide Pigment Codes Mean? (R110, R130, etc.)

Color codes like R110, Y313, B330, etc., are **commercial grade designations**, generally defined by:

- Base color (R = red, Y = yellow, B = black)
- Color index or manufacturer code
- Reflect differences in:
  - Hue (e.g., R110 = brighter red, R180 = deeper red)
  - Particle size
  - Processing method (wet vs. dry)
  - Application focus (coating, plastic, construction)

These codes are **not standardized internationally**, and may vary slightly between manufacturers.

## 6. What Are the Key Specifications on a COA (Certificate of Analysis)?

A typical COA for iron oxide red pigment (e.g., Fe<sub>2</sub>O<sub>3</sub>, R130) includes:

Test Item	Typical Range
Fe <sub>2</sub> O <sub>3</sub> Content (%)	≥ 95%
Moisture (%)	≤ 1.0%
Oil Absorption (g/100g)	15–25
pH Value	4.0–8.0
Residue on Sieve (325 mesh)	≤ 0.3%
Tinting Strength (%)	95–105 (relative to standard)
Volatile Matter at 105°C (%)	≤ 1.0%
Color Shade	Compared to reference standard

COAs ensure the product is consistent and suitable for its end-use (e.g., coatings, plastics, etc.).

## Conclusion

Iron oxide pigments, with their outstanding stability, non-toxicity, and wide range of vibrant colors, play a vital role across multiple industries—from construction and coatings to plastics and cosmetics. Their manufacturing process—whether through dry thermal oxidation or carefully controlled wet precipitation—directly influences pigment properties such as hue, particle size, and application performance. Understanding how these pigments are formed, how color shades like red, yellow, and black are adjusted, and how commercial grades are designated (e.g., R110, R130) allows formulators and manufacturers to select the right pigment for their specific needs.

With precise control over production parameters such as reaction temperature, oxidation rate, and milling fineness, manufacturers can tailor pigments for optimal performance in various end-use scenarios. As demand grows for environmentally safe and high-performance pigments, iron oxides continue to be a trusted and versatile solution.



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