

Iron Oxides

1 Nonproprietary Names

USP–NF: Ferric Oxide

2 Synonyms

- (a) Iron oxide black: *Bayferrox 306*; black magnetic oxide; black oxide, precipitated; black rouge; CI 77499; E172; ethiops iron; ferric ferrous oxide; ferrosferric oxide; *Ferroxide 78P*; *Ferroxide 88P*; iron oxide; iron (II, III) oxide; iron oxides (Fe_3O_4); magnetite; *Mapico Black EC*; pigment black 11; *Sicovit B80*; *Sicovit B84*; *Sicovit B85*; triiron tetraoxide.
- (b) Iron oxide red: anhydrous ferric oxide; anhydrous iron (III) oxide; *Bayferrox 105M*; CI 77491; diiron trioxide; E172; *Ferroxide 212P*; *Ferroxide 226P*; hematite; iron sesquioxide; jeweler's rouge; pigment red 101; red ferric oxide; *Sicovit R30*.
- (c) Iron oxide yellow monohydrate: E172; hydrated ferric oxide; iron (III) oxide monohydrate, yellow; pigment yellow 42; yellow ferric oxide. Iron (III) oxide hydrated: *Bayferrox 920Z*; CI 77492; ferric hydroxide; ferric hydroxide oxide; ferric hydrate; ferric oxide hydrated; *Ferroxide 505P*; *Ferroxide 510P*; iron hydrate; iron hydroxide; iron hydroxide oxide; *Mapico Yellow EC*; *Sicovit Y10*; yellow ochre; yellow iron oxide.

3 Chemical Name and CAS Registry Number

Iron oxides [1332-37-2]

- (a) Iron oxide black [1317-61-9] and [12227-89-3]
(b) Iron oxide red [1309-37-1]
(c) Iron oxide yellow [51274-00-1] (monohydrate); [20344-49-4] (ferric hydroxide oxide); [12259-21-1] (hydrated ferric oxide).

4 Empirical Formula and Molecular Weight

- (a) $\text{FeO}\cdot\text{Fe}_2\text{O}_3$ 231.54
(b) Fe_2O_3 159.69
(c) $\text{Fe}_2\text{O}_3\cdot\text{H}_2\text{O}$ 177.7 (monohydrate);
 $\text{FeO}(\text{OH})$ 88.85 (hydroxide oxide).

5 Structural Formula

Iron oxides are defined as inorganic compounds consisting of any one of or combinations of synthetically prepared iron oxides, including the hydrated forms.

6 Functional Category

Colorant.

7 Applications in Pharmaceutical Formulation or Technology

Iron oxides are widely used in cosmetics, foods, and pharmaceutical applications as colorants and UV absorbers.⁽¹⁻³⁾ As a result of the regulations affecting some synthetic organic dyestuffs, the use of iron oxides (inorganic colorants) is becoming increasingly important. However, iron oxides also have restrictions in some countries on the quantities that may be consumed, and technically their use is restricted because of their limited color range and their abrasiveness.

8 Description

Iron oxides occur as yellow, red, black, or brown powder. The color depends on the particle size and shape, and crystal structure.

9 Pharmacopeial Specifications

See Table I. See also Section 18.

Table I: Pharmacopeial specifications for iron oxide (red and yellow).

Test	USP 40–NF 35 S1
Identification	+
Water-soluble substances	1.0%
Acid-insoluble substances	0.3%
Organic colors and lakes	+
Mercury	$\leq 3 \mu\text{g/g}$
Arsenic	$\leq 3 \mu\text{g/g}$
Lead	0.001%
Assay (on ignited basis)	97.0–100.5%

10 Typical Properties

Density

5.1 g/cm^3 for iron oxide black ($\text{FeO}\cdot\text{Fe}_2\text{O}_3$);

5.2 g/cm^3 for iron oxide red (Fe_2O_3);

4.1 g/cm^3 for iron oxide yellow ($\text{Fe}_2\text{O}_3\cdot\text{H}_2\text{O}$).

Melting point 1565°C for iron oxide red (Fe_2O_3). Iron oxide yellow ($\text{Fe}_2\text{O}_3\cdot\text{H}_2\text{O}$) and iron oxide black ($\text{FeO}\cdot\text{Fe}_2\text{O}_3$) are not stable above 80–120°C and undergo dehydration (iron oxide yellow) or oxidation (iron oxide black) transforming into iron oxide red.

Solubility Soluble in mineral acids; insoluble in water.

11 Stability and Storage Conditions

Iron oxides should be stored in well-closed containers in a cool, dry place.

12 Incompatibilities

Iron oxides have been reported to make hard gelatin capsules brittle at higher temperatures when the residual moisture is 11–12%. This factor affects the use of iron oxides for coloring hard gelatin capsules, and will limit the amount that can be incorporated into the gelatin material.

13 Method of Manufacture

Three main manufacturing processes are currently applied for iron oxide pigments:⁽⁴⁾

- (a) Solid-state reactions (red, black and brown): calcination of black or yellow iron oxides to red iron oxide; thermal decomposition of ferrous sulfate.
- (b) Precipitation process (red, orange, yellow and black): treatment of ferrous sulfate solutions with alkali and oxidation. The Penniman–Zoph process uses ferrous sulfate, alkali, iron powder and air or oxygen.
- (c) Laux process or aniline process (red, yellow, and black): reduction of nitrobenzene to aniline with iron.