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Iron Oxide Red

Alternate Names: Ferric Oxide, Red Iron Oxide, RIO, Iron(III) oxide, Fe_2O_3, Hematite

Description: Synthetic Hematite

Oxide	Analysis	Formula	Tolerance
Fe2O3	95.00%	1.00	
H2O	5.00%	n/a	
Oxide Weight		160.00	
Formula Weight		168.42	

Notes

Synthetic red iron oxide is the most common colorant in ceramics and has the highest amount of iron. It is available commercially as a soft and very fine powder made by grinding ore material or heat processing ferrous/ferric sulphate or ferric hydroxide. During firing all irons normally decompose and produce similar colors in glazes and clay bodies (although they have differing amounts of Fe metal per gram of powder). Red iron oxide is available in many different shades from a bright light red to a deep red maroon, these are normally designated by a scale from about 120-180 (this number designation should be on the bags from the manufacturer, darker colors are higher numbers), however, in ceramics these different grades should all fire to a similar temperature since they have the same amount iron. The different raw colors are a product of the degree of grinding.

In oxidation firing iron is very refractory, so much so that it is impossible, even in a highly melted frit, to produce a metallic glaze. It is an important source for tan, red-brown, and brown colors in glazes and bodies. Iron red colors, for example, are dependent on the crystallization of iron in a fluid glaze matrix and require large amounts of iron being present (eg. 25%). The red color of terra cotta bodies comes from iron, typically around 5% or more, and depends of the body being porous. As these bodies are fired to higher temperatures the color shifts to a deeper red and finally brown. The story is similar with medium fire bodies.

In reduction firing iron changes its personality to become a very active flux. Iron glazes that are stable at cone 6-10 in oxidation will run off the ware in reduction. The iron in reduction fired glazes is known for producing very attractive earthy brown tones. Greens, greys and reds can also be achieved depending on the chemistry of the glaze and the amount of iron. Ancient Chinese celadons, for example, contained around 2-3% iron.

Particulate iron impurities in reduction clay bodies can melt and become fluid during firing, creating specks that can bleed up through glazes. This phenomenon is a highly desirable aesthetic in certain types of ceramics, when the particles are quite large the resultant blotch in the glaze surface is called a blossom.

Iron oxide can gel glaze and clay slurries making them difficult to work with (this is especially a problem where the slurry is deflocculated).

Iron oxide particles are very small, normally 100% of the material will pass a 325 mesh screen (this is part of the reason iron is such a nuisance dust). As with other powders of exceedingly small particle size, agglomeration of the particles into larger ones can be a real problem. These particles can resist break down, even a powerful electric mixer is not enough to disperse them (black iron oxide can be even more difficult). In such cases screening a glaze will break them down. However screening finer than 80 mesh is difficult, this is not fine enough to eliminate the speckles that iron can produce. Thus ball milling may be the only solution if the speckle is undesired.

Red iron oxides are available in spheroidal, rhombohedral, and irregular particle shapes. Some high purity grades are specially controlled for heavy metals and are used in drugs, cosmetics, pet foods, and soft ferrites. Highly refined grades can have 98% Fe_2O_3 but typically red iron is about 95% pure and very fine (less than 1% 325 mesh). Some grades of red iron do have coarser specks in them and this can result in unwanted specking in glaze and bodies (see picture).

High iron raw materials or alternate names: burnt sienna, crocus martis, Indian red, red ochre, red oxide, Spanish red. Iron is the principal contaminant in most clay materials. A low iron content, for example, is very important in kaolins used for porcelain.

One method of producing synthetic iron oxide is by burning solutions of Ferric Chloride (spent pickle liquor from the steel industry) to produce Hydrochloric Acid (their main product) and Hematite (a byproduct). 100% pure material contains 69.9% Fe.

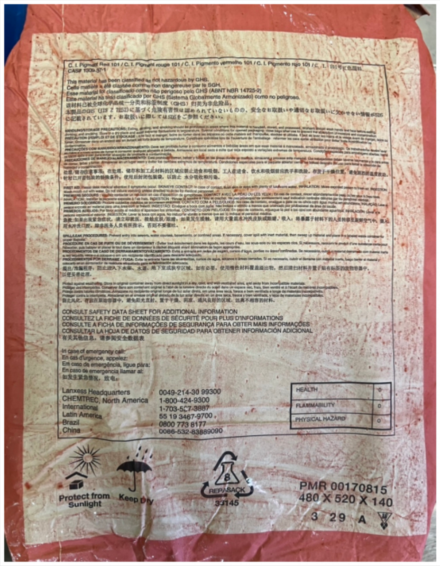
We have received some info about the ability of CaO to bleach the color of iron in bodies (as noted by Hermann Seger). This relates to a chemical reaction between lime, iron, and some of the silica and alumina of the clay, to form a new buff-coloured silicate. He found that this bleaching action is most marked when the percentage of lime is three times that of the iron. Of course, the presence of lime in a body produces rapid softening making it impossible to manufacture vitrified products.

Related Information

Lanxess iron oxide original container bag - Front

This picture has its own page with more detail, click here to see it.

Lanxess iron oxide original container bag - back



This picture has its own page with more detail, click here to see it.

Iron oxide powder is available in many colors. Here are three.

This picture has its own page with more detail, click here to see it.

How can there be so many colors? Because iron and oxygen can combine in many ways. In ceramics we know Fe_2O_3 as red iron and $Fe3O_4$ as black iron (the latter being the more concentrated form). But would you believe there are 6 others (one is $Fe_{13}O_{19}$!). And four phases of Fe_2O_3. Plus more iron hydroxides (yellow iron is Fe(OH)3).

Here is what can happen with iron-oxide-based overglazes

This picture has its own page with more detail, click here to see it.

Since iron oxide is a strong flux in reduction, iron-based pigments can run badly if applied too thickly.

FeO (iron oxide) is a very powerful flux in reduction

This picture has its own page with more detail, click here to see it.

This cone 10R glaze, a tenmoku with about 12% iron oxide, demonstrates how iron turns to a flux, converting from Fe_2O_3 to FeO, in reduction firing and produces a glaze melt that is much more fluid. In oxidation, iron is refractory and does not melt well (this glaze would be completely stable on the ware in an oxidation firing at the same temperature, and much lighter in color).

How do black, red and yellow iron additions compare in a glaze?

This picture has its own page with more detail, click here to see it.

Example of 5% black iron oxide (left), red iron oxide (center) and yellow iron oxide (right) added to G1214W glaze, sieved to 100 mesh and fired to cone 8. The black is slightly darker, the yellow has no color? Do you know why?

Yellow, black and red Iron oxide in a buff burning body at cone 6 oxidation

This picture has its own page with more detail, click here to see it.

Plainsman M340 buff cone 6 stoneware. 3% iron was added has been added to each of these. The yellow iron (left) is clearly not as concentrated (and not mixed in as well). The black (center) gives a maroon color.

Does iron oxide stain a dolomite body red? Nope!

This picture has its own page with more detail, click here to see it.

These fired bars are the L4410P low temperature clay body (it replaces the traditional 50% talc with 40% dolomite and 10% nepheline). These bars are fired from cone 5 down to cone 06 (top to bottom). The body contains 4% red iron oxide, this would normally be enough to produce a bright red fired color. But clearly, the dolomite is killing its development. A better option is to use the L4170 plastic terra cotta (or its L4170B casting version).

Iron-Red high temperature reduction fired glaze

This picture has its own page with more detail, click here to see it.

This recipe, our code 77E14A, contains 6% red iron oxide and 4% tricalcium phosphate. But the color is a product of the chemistry. The glaze is high Al_2O_3 (from 45 feldspar and 20 kaolin) and low in SiO_2 (the recipe has zero silica). This calculates to a 4:1 Al_2O_3:SiO_2 ratio, very low and normally indicative of a matte surface. The iron oxide content of this is half of what is typical in a beyond-tenmoku iron crystal glaze (those having enough iron to saturate the melt and precipitate as crystals during cooling). The color of this is also a product of some sort of iron crystallization, but it is occuring in a low-silica, high-alumina melt with phosphate and alkalis present. Reducing the iron percentage to 4% produces a yellow mustard color (we thus named this "Red Mustard").

Reduction high temperature iron crystal glaze

This picture has its own page with more detail, click here to see it.

This is what about 10% iron and some titanium and rutile can do in a transparent base glossy glaze (e.g. G1947U) with slow cooling at cone 10R on a refined porcelain.

Cone 10 reduction fired transparent glaze with 12% iron oxide

This picture has its own page with more detail, click here to see it.

Additions of iron oxide are coloring, fluxing and crystallizing this base transparent

This picture has its own page with more detail, click here to see it.

Iron oxide is an amazing glaze addition in reduction. Here, I have added it to the G1947U transparent base. It produces green celadons at low percentages. Still transparent where thin, 5% produces an amber glass (and the iron reveals its fluxing power). 7% brings opacity and tiny crystals are developing. By 9% color is black where thick, at 11% where thin or thick - this is "tenmoku territory". 13% has moved it to an iron crystal (what some would call Tenmoku Gold or Teadust), 17% is almost metallic. Past that, iron crystals are growing atop others. These samples were cooled naturally in a large reduction kiln using the C10RPL firing schedule, the crystallization mechanism would be heavier if it were cooled more slowly (or less if cooled faster). The 7% one in this lineup is quite interesting, a minimal percentage of cobalt-free black stain could likely be added to create an inexpensive and potentially non-leaching jet-black glossy.

What 1% iron oxide does in a talc matte at cone 10R

This picture has its own page with more detail, click here to see it.

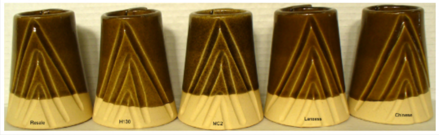
The body is Plainsman H450. Both have a black engobe (L3954N) applied to the insides and half way down the outside during leather hard stage (the insides are glazed with Ravenscrag GR10-C talc matte). The outer glaze on the left has 1% iron added to the base matte recipe. The one on the right has no iron. Notice how differnent the glazes are over the black engobe.

Iron oxide particle agglomerates produce heavy specking

This picture has its own page with more detail, click here to see it.

5 different brand names of iron oxide at 4% in G1214W cone 5 transparent glaze. The specks are not due to particle size, but differences in agglomeration of particles. Glazes employing these iron oxides obviously need to be sieved to break down the clumps.

Comparing the fired glaze specks from different iron oxide brands



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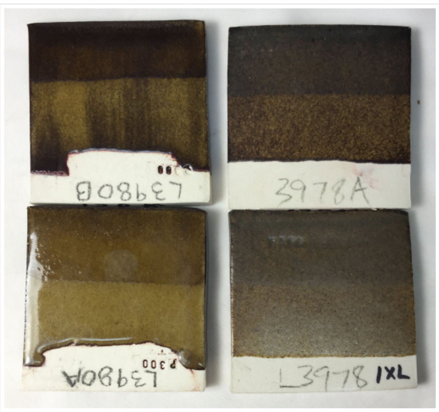
Five different brand names of iron oxide at 4% in G1214W cone 5 transparent glaze. The glazes have been sieved to 100 mesh but remaining specks are still due to agglomeration of particles, not particle size differences.

4% iron oxide in a clear glaze. Unscreened. The result: Fired specks.

This picture has its own page with more detail, click here to see it.

Iron oxide is a very fine powder. Unfortunately it can agglomerate badly and no amount of wet mixing seems to break down the lumps. However putting the glaze through a screen, in this case, 80 mesh, does reduce them in size. Ball milling would remove them completely. Other oxide colorants have this same issue (e.g. cobalt oxide). Stains disperse much better in slurries.

What a difference the iron oxide makes in these two cone 6 glazes



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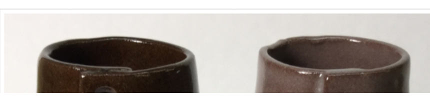
Top two samples: Bayferrox 120M. Bottom two samples: Huntsman #1115. Left two glazes: 4% iron in G2926B glossy base. Right two glazes: 4% in G2934 matte base. The cone 6 firing employed a drop-and-hold schedule.

Adding iron to a clear glaze has cleared the micro-bubbles!



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The glaze on the right is a transparent, G2926B, on a dark burning cone 6 body (Plainsman M390). On the left is the same glaze, but with 4% red iron oxide added. The entrained microbubbles are gone and the color is deep