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# how to add color to your ceramic art




## a guide to using ceramic colorants, ceramic stains, and ceramic oxides

# How to Add Color to Your Ceramic Art

## A Guide to Using Ceramic Colorants, Ceramic Stains, and Ceramic Oxides

Adding color to your ceramic art can be a tricky proposition. Unlike working with paints, what you put on your prize pot or sculpture can be very different from how it looks before and after firing. As a general rule, ceramic stains and ceramic pigments look pretty much the same before and after firing while ceramic oxides like iron oxide, cobalt oxide, and copper oxide as well as cobalt carbonate and copper carbonate all look very different. In this guide you'll discover a little help to better understand what, how, and why ceramic colorants work in a glaze. Enjoy!

## The World of Ceramic Colorants

by Robin Hopper

The potter's palette can be just as broad as the painter's because there are so many ceramic colorants and combinations to choose from. By combining ceramic oxides, ceramic stains, and ceramic pigments in various proportions, you can get every color in the spectrum.

## The Many Faces of Iron Oxide

by Dr. Carol Marians

Glaze ingredients, the clay body, firing atmosphere, and even kiln-stacking techniques can all affect your firing results. Red iron oxide is one of the ceramic colorants that's quite temperamental and affected by a lot of variables. From dark brown to unusual speckles, red iron oxide can offer a lot for a single ceramic colorant.

## Ceramic Pigments and Ceramic Stains

by Bill Jones

Commercially prepared ceramic pigments, commonly referred to as ceramic stains, expand the potter's palette with infinite color options. With ceramic pigments, you can color the clay, color the glazes, or color both. Ceramic pigments are easy to use and the simplest way to introduce a wide range of color into your work.

## How Lana Wilson Uses Ceramic Pigments

by Annie Chrietzberg

Lana Wilson's work is mostly black and white with bits of vibrant color splashed about. She gets her color from ceramic pigments mixed with a clay slip which she makes from a commercial clay body. She explains how to mix the slip, how much ceramic pigment to add for each color, and how to use the glaze on a finished piece.

# The World of Ceramic Colorants

by Robin Hopper

## Red to Orange

The potter's palette can be just as broad as the painter's. Different techniques can be closely equated to working in any of the two-dimensional media, such as pencil, pen and ink, pastel, watercolor, oils, encaustics or acrylics. We also have an advantage in that the fired clay object is permanent, unless disposed of with a blunt instrument! Our works may live for thousands of years—a sobering thought.

Because a number of colors can only be achieved at low temperatures, you need a series of layering techniques in order to have the fired strength of stoneware or porcelain and the full palette range of the painter. To accomplish this, low-temperature glazes or overglazes are made to adhere to a higher-fired glazed surface, and can be superimposed over already existing decoration. To gain the full measure of color, one has to fire progressively down the temperature range so as not to burn out heat-sensitive colors that can't be achieved any other way. Usually the lowest and last firing is for precious metals: platinum, palladium, and gold.

For the hot side of the spectrum—red, orange, and yellow—there are many commercial body and glaze stains, in addition to the usual mineral colorants. Ceramists looking for difficult-to-achieve colors might want to consider prepared stains, particularly in the yellow, violet, and purple ranges. These colors are often quite a problem with standard minerals, be they in the form of oxides, carbonates, nitrates, sulfates, chlorides or even the basic metal itself.

Minerals that give reds, oranges, and yellows are copper, iron, nickel, chromium, uranium, cadmium-selenium, rutile, antimony, vanadium, and praseodymium. Variations in glaze makeup, temperature and atmosphere profoundly affect this particular color range. The only materials which produce red at high temperatures are copper, iron, and nickel. The results with nickel are usually muted. Reds in the scarlet to vermilion range can only be achieved at low temperatures.

The chart should help pinpoint mineral choices for desired colors (note that the color bars are for guidance only and not representative of the actual colors—Ed.). Colors are listed with the minerals needed to obtain them, approximate temperatures, atmosphere, saturation percentage needed, and comments on enhancing/inhibiting factors. Because of the widely variable nature of ceramic color, there are many generalities here. Where the word "vary" occurs in the column under Cone, it signifies that the intended results could be expected most of the time at various points up to cone 10.

| COLORANT | CONE | ATMOS. | % | COMMENTS |
|---|---|---|---|---|
| **Dark Red** | | | | |
| Copper | Vary | Red. | 0.5%-5% | Best in glazes containing less than 10% clay content, and a high alkaline content. Needs good reduction. In low temperatures it can be reduced during cooling. Good reds as low as cone 018. |
| Iron | Vary | Both | 5%-10% | Good in many glaze bases at all temperatures. Can be improved with the addition of 2%-5% tin oxide. |
| Nickel | 4-10 | Ox. | 5%-8% | Use in barium-saturated glazes. |
| **Burgundy** | | | | |
| Iron | | | | See Dark Red, Iron. |
| Copper | See Dark Red, Copper. | | | Owing to the unstable nature of copper, this colorant can produce a wide range of results. Very controlled reduction firing and cooling are important. |
| **Maroon** | | | | |
| Chrome-Tin Stains | Vary | Ox. | 1%-5% | Use in glazes with calcium. There should be no zinc in the glaze. |
| Copper | Vary | Red. | 0.5%-5% | Best in high alkaline glazes. |
| **Crimson** | | | | |
| Copper + Titanium | 8-10 | Red. | 1%-5% | Try various blends of copper (1%-5%) and titanium (2%-5%). |
| Calcium-Selenium Stains | 010-05 | Ox. | 0.5-5% | Best with special frits. |
| **Indian Red** | | | | |
| Iron | Vary | Both | 5%-10% | Best in high calcium glazes; small amount of bone ash helps. Tin addition up to 5% also helps. Also works well in ash glazes. |
| **Brick Red** | | | | |
| Iron | Vary | Both | 5%-10% | Similar to Indian Red. Tin to 2% helps. |
| **Orange-Brown** | | | | |
| Iron + Rutile | Vary | Both | 1%-10% | Various mixtures (up to 8% iron and 2% rutile) in most glaze bases. |
| Iron + Tin | Vary | Both | 1%-5% | Various mixtures (up to 4% iron and 1% tin) in most glaze bases. Creamier than iron with rutile. |
| **Orange-Red** | | | | |
| Cadmium-Selenium Stains | 012-05 | Ox. | 1%-4% | Best with special frits such as Ferro 3548 or 3278 or both. Helps to opacify with zirconium. |
| **Orange** | | | | |
| Iron | Vary | Both | 1%-5% | Use in tin or titanium opacified glazes. |
| Rutile | Vary | Both | 5%-15% | Many glaze types, particularly alkaline. More successful in oxidation. |
| Copper | 8-10 | Both | 1%-3% | Use in high alumina or magnesia glazes. Addition of up to 5% rutile sometimes helps. |
| **Orange-Yellow** | | | | |
| Iron | Vary | Both | 2%-5% | With tin or titanium opacified glazes. |
| Rutile | Vary | Ox. | 1%-10% | Best with alkaline glazes. |
| **Yellow Ocher** | | | | |
| Iron | Vary | Both | 1%-10% | Use in high barium, strontium or zinc glazes. |
| Iron + Tin | Vary | Ox. | 1%-5% | Various mixtures (up to 3.5% iron and 1.5% tin) in many glaze bases. |
| Iron + Rutile | Vary | Both | 1%-5% | Various mixtures (up to 2.5% iron and 2.5% rutile) in many glaze bases. |
| Vanadium-Zirconian Stains | Vary | Ox. | | 5%-10%Various mixtures in many Zirconium stain glaze bases. |
| **Lemon Yellow** | | | | |
| Praseodymium Stains | Vary | Both | 1%-10% | Good in most glazes. Best in oxidation. |
| **Pale/Cream Yellow** | | | | |
| Iron + Tin | Vary | Both | 2%-5% | Various mixtures (up to 3.5% iron and 1.5% tin) in high barium, strontium or zinc glazes. Titanium opacification helps. |
| Vanadium | Vary | Both | 2%-5% | Use in tin-opacified glazes. |
| Rutile + Tin | Vary | Ox. | 2%-5% | Various mixtures (up to 2.5% iron and 2% tin) in variety of glaze bases. Titanium opacification helps. |

Note: Colors bars are for visual reference only, and do not represent actual colors.

# Yellow-Green to Navy Blue

The cool side of the glaze spectrum (from yellow-green to navy blue) is considerably easier, both to produce and work with, than the warm. In the main, colorants that control this range create far fewer problems than almost any of the red, orange, and yellow range. Some are temperature and atmosphere sensitive, but that's nothing compared to the idiosyncrasies possible with warm colors.

The colorants known for creating cool hues are copper, chromium, nickel, cobalt, iron, and sometimes molybdenum. For variations, some are modified by titanium, rutile, manganese or black stains. The usual three variables of glaze makeup, temperature, and atmosphere still control the outcome, though it is less obvious in this range.

| COLORANT | CONE | ATMOS. | % | COMMENTS |
|---|---|---|---|---|
| **Yellow Green** | | | | |
| Copper + Rutile | Vary | Both | 2%-10% | Various mixtures in a wide variety of glazes, particularly those high in alkaline materials. Almost any yellow glaze to which copper is added will produce yellow green. |
| Chromium | Vary | Both | 0.5%-3% | In yellow glazes without tin or zinc. |
| Chromium | 4-8 | Ox. | 0.25%-1% | In saturated barium glazes. |
| Chromium | 018-015 | Ox. | 0-2% | In high alkaline glazes with no tin. |
| Cobalt | Vary | Both | 0-1% | In any yellow glazes. |
| **Light Green** | | | | |
| Copper | Vary | Ox. | 0-2.5% | In various glazes except those high in barium or magnesium. Best in glazes opacified with tin or titanium. |
| Cobalt | Vary | Both | 0-2% | In glazes opacified with titanium, or containing rutile. |
| **Apple Green** | | | | |
| Chromium | Vary | Both | 0-2% | In various glazes without zinc or tin. Good in alkaline glazes with zirconium opacifiers. Also use potassium dichromate. |
| Copper | | | 1%-2% | See Light Green; use in non-opacified glazes. |
| **Celadon Green** | | | | |
| Iron | Vary | Red | 0.5%-2% | Best with high sodium, calcium or potassium glazes. Do not use with zinc glazes. |
| Copper | Vary | Ox. | 0.5%-2% | Good in a wide range of glazes. |
| Grass Green | | | | |
| Copper | 010-2 | Ox. | 1%-5% | In high lead glazes; sometimes with boron. |
| Chromium | 018-04 | Ox. | 1%-2% | In high alkaline glazes. |
| **Olive Green** | | | | |
| Nickel | Vary | Both | 1%-5% | In high magnesia glazes; matt to shiny olive green. |
| Iron | Vary | Red. | 3%-5% | In high calcium and alkalines, usually clear glazes. |
| **Hooker's Green** | | | | |
| Copper + Cobalt | Vary | Ox. | 2%-5% | In a wide variety of glaze bases. |
| Cobalt + | Vary | Both | 2%-5% | In a wide variety of glaze Chromium bases: no zinc or tin. Good opacified with zirconium or titanium. |
| **Chrome Green** | | | | |
| Chromium | 06-12 | Both | 2%-5% | In most glazes; no zinc or tin. |
| **Dark Green** | | | | |
| Copper | Vary | Ox. | 5%-10% | Many glaze bases, particularly high barium, strontium, zinc or alkaline with a minimum of 10% kaolin. |
| Cobalt + Chromium | Vary | Both | 5%-10% | Blends of these colorants will give a wide range of dark greens. |
| Cobalt + Rutile | Vary | Both | 5%-10% | Dark greens with blue overtones. |
| **Teal Blue** | | | | |
| Cobalt + Rutile | Vary | Both | 1%-5% | In a wide variety of glazes. |
| Cobalt + Chromium | Vary | Both | 1%-5% | In most glazes without tin or zinc. |

Note: Colors bars are for visual reference only, and do not represent actual colors.

| COLORANT | CONE | ATMOS. | % | COMMENTS |
|---|---|---|---|---|
| **Turquoise** | | | | |
| Copper | Vary | Ox. | 1%-10% | In high alkaline and barium glazes. Bluish with no clay content; tends toward greenish tint with added clay. |
| Copper + Rutile | Vary | Both | 1%-5% | In high alkaline and barium glazes. |
| Copper + Tin | Vary | Ox. | 1%-10% | In high alkaline and barium glazes; usually opaque. |
| **Light Blue** | | | | |
| Nickel | Vary | Ox. | 1%-2% | In high zinc or barium glazes. |
| Rutile | Vary | Red. | 1%-5% | In a wide range of glazes; best with low (10% or less) clay content. |
| Cobalt | Vary | Both | 0.25%-1% | Use in most glazes, particularly those opacified with tin. Also use mixed with small amounts of iron. |
| **Celadon Blue** | | | | |
| Iron | 6-10 | Red. | 0.25%-1% | In high alkaline or calcium clear glazes. Black iron is generally preferable to red iron. |
| **Wedgewood Blue** | | | | |
| Cobalt + Iron | Vary | Both | 0.5%-2% | In most glazes; small amounts of cobalt with iron, manganese or nickel yield soft blues. Added tin gives pastel blue. |
| Cobalt + Manganese | Vary | Both | 0.5%-2% | |
| Cobalt + Nickel | Vary | Both | 0.5%-2% | |
| Cobalt | 4-10 | Both | 0.5%-3% | In high zinc glazes. |
| Nickel | 4-10 | Ox. | 1%-3% | In high barium/zinc glazes; likely to be crystalline. |
| **Blue Gray** | | | | |
| Nickel | Vary | Ox. | 0.5%-5% | In high barium/zinc glazes. |
| Rutile | Vary | Red. | 2%-5% | In a wide variety of glazes, particularly high alumina or magnesia recipes. |
| Cobalt + Manganese | Vary | Both | 0.5%-2% | In most opaque glazes. |
| Cobalt | Vary | Ox. | 0.5%-5% | In high zinc glazes. |
| **Ultramarine** | | | | |
| Cobalt | Vary | Both | 0.5%-5% | In high barium, colemanite, and calcium glazes; no zinc, magnesium or opacification. |
| **Cerulean Blue** | | | | |
| Cobalt | Vary | Both | 0.5%-5% | In glazes containing cryolite of fluorspar. |
| Cobalt + Chromium | Vary | Both | 2%-5% | In most glazes except those containing zinc or tin. |
| **Prussian Blue** | | | | |
| Nickel | 6-10 | Ox. | 5%-10% | In high barium/zinc glazes. |
| Cobalt + Manganese | Vary | Both | 5%-10% | In most glaze bases. |
| Cobalt + Manganese | Vary | Both | 5%-10% | In most glazes; for example, cobalt 2%, chromium 2% and manganese 2%. |
| Navy Blue | | | | |
| Cobalt | Vary | Both | 5%-10% | In most glazes except those high in zinc, barium or magnesium. |

# Indigo to Purple

The indigo-to-purple part of the color wheel is small but significant. The colorants that produce this range are nickel, cobalt, manganese, umber, iron, chromium, rutile ilmenite, copper, iron chromate, and black stains. In short, one could say that the colorants needed include just about the whole group that are used for all the other colors in the spectrum. The only ones I haven't talked about previously in this articles series are umber, ilmenite, iron chromate, and black stains.

**Black Stains** Formulated from a variable mixture of other colorants, black stains are usually rather expensive due to their being saturations of colorant materials. Various companies produce black stains usually from a combination of iron, cobalt, chromium, manganese, iron chromate and sometimes nickel mixed with fillers and fluxes such as clay, feldspar and silica. I use the following recipe:

### Black Stain

| | |
|---|---|
| Chromium Oxide | 20 % |
| Cobalt Carbonate or Oxide | 20 |
| Manganese Dioxide | 20 |
| Red Iron Oxide | 20 |
| Feldspar (any) | 8 |
| Kaolin (any) | 8 |
| Silica | 4 |
| | 100 % |

This mixture is best ball-milled for a minimum of four hours to limit its tendency toward cobalt specking, and to make sure that the colorants are thoroughly mixed. Because any black stain is a very concentrated mixture, only small amounts are normally needed to cause a strong effect. In a clear glaze, a maximum of 5% should produce an intense black. In opaque glazes, more stain than that may be needed. Black stains and white opacifiers mixed together will produce a range of opaque grays. Stains, like other ceramic materials, are subject to the three variables of glaze makeup, temperature and atmosphere.

Outside the color wheel one finds tones of brown, gray, and black. These moderate other colors. A color wheel could, I suppose, include the range of opacifiers since they also have a strong role in affecting color. The toning influence of brown, gray, and black is just as much opacifying in result as are the white opacifiers such as tin, titanium, and zirconium compounds such as Zircopax, Opax, Superpax, and Ultrox. Slight additional increments of any of these colors will render most glazes, colored or not, progressively darker as they are added.

*Excerpted from* The Ceramic Spectrum: A Simplified Approach to Glaze and Color Development, *published by The American Ceramic Society.*

Note: Colors bars are for visual reference only, and do not represent actual colors.

| COLORANT | CONE | ATMOS. | % | COMMENTS |
|---|---|---|---|---|
| **Indigo** | | | | |
| Nickel | Vary | Ox. | 8%-15% | Use in high barium/zinc glazes. Also likely to crystallize. |
| Cobalt + Manganese | Vary | Both | 5%-10% | Various mixtures in most glazes. |
| Cobalt + Black Stain | Vary | Both | 5%-8% | Various mixtures in most glazes. |
| **Violet** | | | | |
| Cobalt | Vary | Both | 5%-10% | In high magnesium glazes. |
| Nickel | Vary | Ox. | 1%-10% | In some saturated-barium glazes. |
| Manganese | Vary | Both | 5%-10% | In high alkaline glazes. |
| Copper | Vary | Ox. | 8%-10% | In some saturated-barium glazes. |
| **Purple** | | | | |
| Copper | 6-10 | Both | 8%-10% | In high barium and barium/zinc glazes. |
| Copper | 8-10 | Red. | 1%-5% | In copper red glazes opacified with titanium. |
| Nickel | Vary | Ox. | 5%-10% | In some high barium glazes. |
| Cobalt | Vary | Both | 5%-10% | In high magnesium glazes. |
| Manganese | 04-10 | Ox. | 5%-10% | In high alkaline and barium glazes. |
| Iron | 8-10 | Red. | 8%-10% | In high calcium glazes; likely to crystallize. |
| Copper + Cobalt | Vary | Red. | 2%-8% | Various mixtures in many glazes. |
| Chrome + Tin + Cobalt | Vary | Ox. | 2%-8% | Various mixtures in many glazes. |
| **Mauve or Lilac** | | | | |
| Cobalt | Vary | Both | 1%-5% | In high magnesium glazes. |
| Nickel | Vary | Ox. | 1%-5% | In some saturated-barium glazes. |
| **Pink** | | | | |
| Cobalt | Vary | Ox. | 1%-3% | In high magnesium glazes opacified with tin. Also in very low alumina content glazes. |
| Copper | Vary | Red. | 0.2%-2% | In copper red glazes with titanium. |
| Copper | 6-10 | Ox. | 0.2%-3% | In high magnesium or high alumina glazes. |
| Copper | 8-10 | Red. | 5%-10% | In copper red glazes opacified w/min. 5% titanium. |
| Chromium | Vary | Ox. | 1%-2% | In calcium glazes opacified with 5%-10% tin. |
| Iron | Vary | Ox. | 1%-5% | In calcium glazes opacified with tin. |
| Rutile | Vary | Both | 5%-10% | In high calcium and some ash glazes. |
| Nickel | 018-010 | Ox. | 1%-3% | In high barium glazes with some zinc. |
| Manganese | Vary | Both | 1%-5% | In alkaline glazes opacified with tin or titanium. Also in high alumina glazes. |
| **Brown** | | | | |
| Iron | Vary | Both | 3%-10% | In most glazes. |
| Manganese | Vary | Both | 2%-10% | In most glazes. |
| Nickel | Vary | Both | 2%-5% | In high boron, calcium, and lead glazes. |
| Chromium | Vary | Both | 2%-5% | In high zinc glazes. |
| Umber | Vary | Both | 2%-10% | In most glazes. |
| Ilmenite | Vary | Both | 2%-10% | In most glazes. High calcium may yield bluish tint. |
| Rutile | Vary | Both | 5%-10% | In most glazes; golden brown. |
| **Gray** | | | | |
| Iron | Vary | Red. | 2%-4% | In many glaze bases; gray brown. |
| Iron Chromate | Vary | Both | 2%-5% | In most glaze bases without zinc or tin. |
| Nickel | Vary | Both | 2%-5% | In most glaze bases; gray brown. |
| Copper | 8-10 | Both | 3%-10% | In high magnesium glazes. Warm gray in reduction; cold gray in oxidation. |
| Cobalt + Nickel | Vary | Both | 1%-5% | Blue gray in most glazes. |
| Cobalt + Manganese | Vary | Both | 1%-5% | Blue gray to purple gray in most glazes. |
| Black Stain | Vary | Both | 1%-5% | Shades of gray in most opacified glazes. |
| **Black** | | | | |
| Iron | Vary | Both | 8%-12% | In high calcium glazes—the temmoku range. |
| Copper | Vary | Both | 8%-10% | In a wide range of glazes. |
| Cobalt | Vary | Both | 8%-10% | Blue black in most glazes except those high in zinc and magnesium. |
| Black Stain | Vary | Both | 3%-10% | In most zinc-free, non-opacified glazes. |

# The Many Faces of Iron Oxide:

by Dr. Carol Marians

One of the more fascinating, but sometimes frustrating parts of ceramics is learning to balance the innumerable factors that affect the outcome of a firing. Glaze ingredients, the clay body used, firing cycles, atmospheres, kiln-stacking techniques, and geography (to name a few variables) can all affect firing results.

This may be frustrating if you don't control those variables, but if you do, there is opportunity for new discoveries. By changing just one variable, the same glaze recipe can be deliberately manipulated to yield different results. In this instance, I decided to investigate one variable in an iron-rich glaze: the cooling period.

I achieved greatly differing results in a single glaze with a single clay body, consistent glaze thickness and application, and the same heating schedule for all of the firings. The differences in the resulting appearance of the glaze on the pots came exclusively from their heat treatment after they reached maturity.

When the witness cone bends, the glaze should be fully vitrified. The kiln has reached temperature, but has not yet begun to cool. I studied what happens between that point and the return of the kiln's temperature to room temperature. I found that I could get a glossy black surface, a densely textured rough surface, a golden red/mud color, or anything in between, just from different cooling schedules.

## How does this happen?

At the top of the firing cycle, the glaze is matured, but not watery; it doesn't flow off the pot. At this point, the glaze is not a homogenous melt, but a mixture of several melts. It is not fully blended. It may contain a dissolved second phase—in our case an iron compound—analogous to sugar dissolved in hot tea. More sugar dissolves in hot tea; less as the tea cools. The sugar precipitates as crystals as the tea cools. Our glaze, when melted, has a dissolved iron compound—the "sugar" in the tea. The iron precipitates as the glaze cools. So how does the iron form in the glaze?

Glaze is more complex and more viscous than tea, inhibiting motion. The iron crystals cannot precipitate and sink to the bottom of the glaze, nor can they grow very large, as the iron ions do not congregate in the same location. Instead, as the glaze cools, the dissolved iron separates out, forming numerous small crystals suspended in the glaze. The number of particles, and their eventual size, is affected by the surface texture of the underlying clay body, the cooling speed of the melt, the thickness of the glaze application, and several other factors. The competition between the number and size of particles as the glaze cools results in the variety of desirable effects (*see accompanying figures*).

As it cools, the glaze becomes progressively more viscous and less

## recipe

The glaze used in these tests is a minor modification of the glaze GA16, from Michael Bailey's *Cone 6 Glazes*, poured thick on Georgies Ceramic Supply's G Mix 6 clay body.

### GA16 Variation
(Cone 6)

| | |
|---|---|
| Bone Ash | 4.6 % |
| Dolomite | 13.6 |
| Lithium Carbonate | 4.6 |
| Red Iron Oxide | 9.1 |
| Unispar | 22.7 |
| Bentonite | 1.8 |
| OM4 Ball Clay | 20.9 |
| Silica | 22.7 |
| | 100.0 % |

### Empirical Formula

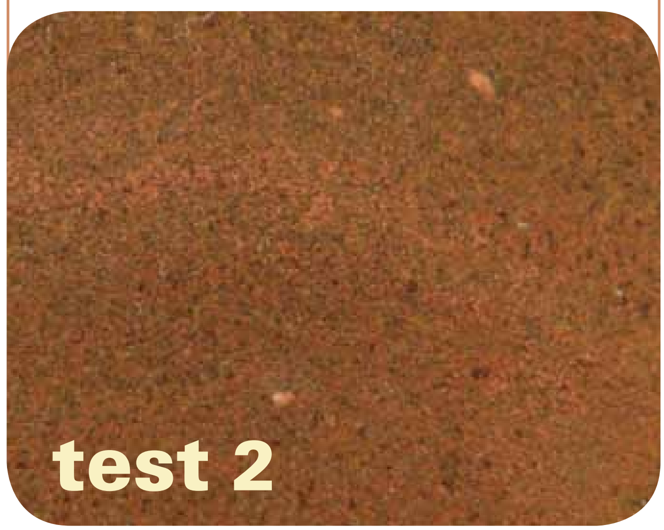
| | |
|---|---|
| CaO | 0.4126 |
| K2O | 0.0454 |
| Li2O | 0.2013 |
| MgO | 0.2521 |
| Na2O | 0.0886 |
| Al2O3 | 0.3424 |
| SiO2 | 2.7566 |
| P2O5 | 0.0480 |
| Fe2O3 | 0.1912 |
| TiO2 | 0.0104 |


**Cool down: A continuous cool from Cone 6 to 1500°F at –150° per hour.**

Results: This is the cool-down profile from Hesselberth and Roy. It gave a predominantly glossy black glaze, not greatly different from the quick cool, but with a hint of variegated color. I could see isolated metallic bronze and red flecks, but no crystals breaking the surface.

**Cool down: An uncontrolled drop from 2200°F to 1750°F, then –50° per hour from 1750°F to 1500°F.**

Results: The cooling was slower from 2200°F down to 1450°F. Because the solubility of iron in glaze decreases at lower temperatures, I cooled at ⅓ the speed between 1750°F and 1500°F. The result was a substantially textured surface, with much visible variation, and crystals of a variety of colors breaking the surface. The glossy black was gone, and the surface variation uniformly distributed. There were a relatively small number of largish particles. The color was intermixed red, bronze and mud brown. Bronze predominated where the glaze was thickest. I interpreted this as substantial particle growth below 1750°F, with little precipitation of new particles.




mobile, until it reaches a temperature at which it "freezes" and nothing can move or precipitate within it. If the glaze is held at a temperature high enough to permit continued mobility of the iron into progressively larger crystals, but low enough that the glaze doesn't run off the pot, the surface will become matt. The multitude of tiny iron particles disrupt light transmission. Otherwise, the glaze solidifies with the same smooth, glossy surface as it had while fully melted. If the glaze is cooled quickly, few visible, very small particles form. Most of the visible color is the reflection off the smooth surface. This gives an aesthetically pleasing, clear, glossy, black glaze, somewhat akin to a temmoku (*see test 1*). The opacity and depth of the glossy black show that the glaze can dissolve quite a lot of iron.

As the glaze cools and becomes more viscous, crystals begin to form at edges and imperfections in the body. If the glaze layer is thin, different kinds and shapes of crystal will form. If the crystals are stuck to the clay body at the bottom of a thick opaque glaze layer, they will be largely invisible. Crystals that float on top of the glaze give the appearance of sandpaper, which can present utilitarian problems. We want the crystals near the surface but not on it, large enough to create surface and color effects, but not be overwhelming.

A series of cool-down profiles with lots of jigs and jags showcases a different phase, exposing a range of surface effects. This translates into profiles with one or more narrow temperature ranges with extreme slow cooling and/or long holds, and possibly no retarded cooling outside the selected ranges. Since extended firing cycles can be costly, I framed my experiments with a maximum extension to the firing cycle of four hours.


**Cool down: An uncontrolled drop to 1750°F, then –50° per hour to 1600°F, a hold at 1600°F for one hour, then –50° per hour to 1500°F.**

Results: By adding a one-hour hold at 1600°F, the color shifted from gold/brown to red/gold. The red and brown regions followed the throwing lines, indicating that glaze thickness has significant influence. The strength of this effect showed there is a critical region for this glaze's development somewhere near the temperature 1600°F.


**Cool down: An uncontrolled drop to 1750°F, hold at 1750°F for half an hour, then –50° per hour to 1650°F, hold at 1650°F for one hour, then –50° per hour to 1500°F.**

Results: Adding a half-hour hold at 1750°F and a one-hour hold at 1650°F gave smaller particles and a near-smooth, lustrous satin, variegated bronze glaze with small specks of red and brown. The original glossy black was completely gone. Color variation in the throwing line showed the considerable effect that glaze thickness has. The half-hour hold at 1750°F facilitated the formation of a large
5 number of small particles, leaving little free iron to add to crystal growth later. This uniform result was much like a pointillist painting, with exceedingly fine points. Moving the hold from 1600°F up to 1650°F could have a similar effect. Alternatively, we could see this change as a result of the glaze spending more time in the critical temperature interval for crystal development.


**Cool down: An uncontrolled drop to 1800°F, then –50° per hour to 1450°F.**

Results: As the previous test result could have come from extended time in the crystal growing range, or specifically from the hold at 1650°F and 1750°F, I gave this firing just as much time in the sensitive zone, but uniform decrease in temperature over the extended region. The results were similar to the previous test, but with larger grain size and a lizard-skin feel to the texture. The glaze was mottled and less uniform. The smooth satin look was gone. I concluded one of the holds in the previous test hit the "sweet spot," at which point many small particles form. I did not know at which level.


**Cool down: An uncontrolled drop to 2000°F, then –50° per hour to 1650°F.**

Results: The slow cool from 2000°F to 1650°F gave a surface and color as in test 1, with a much greater number of gold particles. This also shows that the effects of test 4 depended on the 1650°F hold. This critical test showed that the greater color effect I wanted needed two holds.

**Cool down: From Cone 6 to 2100°F at –50° per hour, then uncontrolled cooling to 1700°F, then –25° per hour to 1600°F.**

Results: To test a second slow-cooling region, the kiln was cooled quickly from the top temperature to 1700°F, then slowly to 1600°F. The result was an intensely variegated effect with relatively few but larger particles in red and brown. The throwing lines were not prominent, so glaze thickness was not as important. The texture is lizard-skin satin, not the gloss of tests 1 and 5, nor the smooth satin of test 4. This result was related, but not quite like anything previous. This could be a jumping off point for a new series of tests.


I started out with the firing profile in Hesselberth and Roy's *Mastering Cone 6 Glazes*. The ramp for reaching temperature was a fast rise (200°F in the first hour, then 500°F per hour to 2100°F) until the last three hours, which had a rise of approximately 30°F per hour. Orton cones showed a hard Cone 6. These firings were done in a very old Skutt 1227 with a computer controller. I examined the results of my firings and based my next firings on those results, only changing one factor with each firing. I chose 1450°F as a low end for controlled cooling, selecting intervals for markedly slow cooling in the temperature range 2200°–1450°F.

## Speculation

With this limited series of tests, I produced a variety of textures and colors, by "poking" the cool-down profile. Each firing included several identically glazed test pieces distributed throughout the kiln. I obtained an encouraging indication that the different results were caused by the cooling-down profiles and not extraneous effects. I next will explore whether maximal particle size growth takes place "hotter" than the temperature at which the greatest number of particles is formed. Cooling to approximately 1600°F, then reheating to around 1800°F should obtain both good numbers and development of microcrystals.

*the author Dr. Carol Marians holds a Ph.D. in materials science from the Massachussetts Institute of Technology, and makes pots at Basic Fire studio in Portland, Oregon.*

# Ceramic Pigments and Stains

by Bill Jones

Prepared ceramic pigments, commonly referred to as "stains," expand the potter's palette with infinite possibilities. Pigments provide a wide range of color possibilities in clay bodies, inglazes, underglazes, and onglazes.

In order to get a full range of consistent ceramic colors, pigments are used with metallic oxides and salts, many of which are soluble or toxic, to make them stable. By combining these elements, along with clays, silica, and alumina, the industry has come up with 44 different calcined pigment systems covering the entire color spectrum.

**The raw colors of the assorted stains above are close to the actual fired color.**

Pigments solve some of the problems found in using just plain oxides. For example, when pure chrome oxide is used as a colorant to obtain green, it may fume or volatilize in the kiln leading to absorption into the kiln bricks and shelves. The oxide may also effect the color of the glaze. If tin is present in a white or pastel glaze, the chrome reacts with the tin to create a pink coloration. In addition, if any zinc oxide is present in the glaze, you'll get a dirty-brown color. The solution is to use a green pigment, of which there are several. One such system is the cobalt-zinc-alumina-chromite blue-green pigment system, where varying the amounts of cobalt and chrome oxides produces a range of colors from green to blue-green to blue. Mason 6244 is an example of this pigment.

## Using Pigments

Depending on the use, pigments may be used straight and just mixed with water, but they are more commonly added as colorants in clay bodies and glazes. Some pigments are specifically formulated for clay bodies while some are not suitable at all. When used in clay, pigments are usually used in engobes and slips as a coating for clay rather than pigmenting the entire body. The exception to this would be using stains to tint porcelain for neriage work.

Use in concentrations of 10–15% in clay, using more or less depending on the intensity needed. Add the pigment to the slip and sieve through a 120x mesh screen to ensure adequate dispersion.

Pigments can be used in underglazes for brushing onto greenware or bisque. If used only with water as a medium, some glazes may crawl, so for best results, mix the stains with a frit (for example, Ferro frit 3124). Begin with a mix of 85 frit/15 pigment and test. Transparent gloss glazes applied over the top will heighten the intensity of the colors.

When using pigments in glazes, usually in concentrations of 1–10%, a little more care must be taken because some pigment systems react with materials in a glaze. Some pigments are affected by the presence, or lack of, boron, zinc, calcium, and magnesia. Manufacturers provide information on specific reactions. While most pigments can be used in both oxidation and reduction atmospheres, some are limited to certain maximum temperatures. Again, this information is available from manufacturer websites.

To achieve a wider palette, most pigments can be mixed to achieve even more colors. The exception is that black pigments cannot be used to obtain shades of gray because blacks are made from a combination of several metallic oxides. If low percentages are used, the final color is affected by the predominant oxide in the black pigment.

## Testing and Safety

When using pigments alone or in combination with other pigments and/or oxides, you'll need to test them with the frit, glaze, and slip bases you intend to use. A good starting point is either using some of the published recipes or using frits. Because pigments are expensive to manufacture, their cost is higher than that of ceramic oxides, but you'll find most suppliers will sell ceramic pigments in quantities as small as ¼ pound.

Finally, safety is always an issue. Suppliers are required by law to provide a Material Data Safety Sheet (MSDS), and there are different precautions listed with each pigment or family of pigments. Make sure you read and follow the instructions listed in the MSDS for safe handling.

When used as underglazes, surfaces coming into contact with food must be covered by a food-safe transparent glaze, and glazes containing pigments should be tested for food use.

*Sources:* Understanding Glazes, *by Richard Eppler and Mimi Obstler, The American Ceramic Society, 2005, and Mason Color Works, www.masoncolor.com.*

# How Lana Wilson Uses Ceramic Pigments

by Annie Chrietzberg

Lana Wilson's work is mostly black and white with bits of vibrant color splashed about. She says, "I have a background in painting, and this technique really appeals to the painter in me." She gleaned this current surface treatment from two artists, Denise Smith of Ann Arbor, Michigan, and Claudia Reese, a potter from Texas.

## Simple Slip

To prepare the slip, Wilson takes 100 grams of small pieces of bone dry clay and adds 10–50 grams of a stain. The percentages of stains varies according to the intensity of color she is trying to achieve.

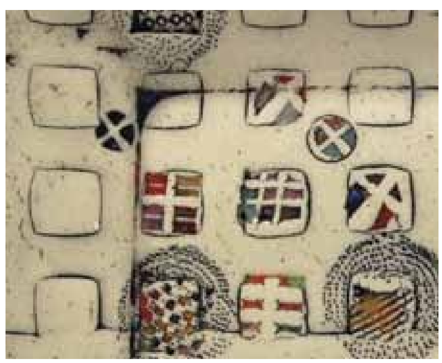
The clay Wilson uses is Half & Half from Laguna, formulated for firing at cone 5, though she fires it to cone 6. This clay body is half porcelain and half white stoneware. It's not as white as porcelain, but it does fire white rather than yellow in oxidation, isn't as finicky as porcelain, and works well with Wilson's making methods. If you're buying clay from the East Coast, she suggests a clay body called Little Loafers from Highwater Clays.

## Easy Application

The technique is simple. On a piece of bisqueware, first brush on black slip or one of the base colors (*figure 1*) then sponge it off, leaving slip in the crevices (*figure 2*). Then, using colored slips dab on bits of color here and there (*figure 3*). Remove some of that with steel wool (*figure 4*). "I can't use water for this step or it will muddy the colors," Wilson explains. **CAUTION**: You must wear a respirator during this stage. In the final step, she dips the piece in a clear glaze, and fires to cone 6. Through lots of experimenting, and with lots more to go, Wilson finds that ending with a dark color on top works best for her.







## Recipes

There are two groups of colored slips. The first group Wilson uses for the base coat that she washes off, leaving color in all the recesses. The accent slips are more intense and removed with steel wool. All stains are Mason stains except for 27496 Persimmon Red, which is from Cerdec. Add the stains and bone dry clay to water and allow to sit for 30–60 minutes so it will mix easier.

**Note:** Stain-bearing slips applied to surfaces that come into contact with food need to be covered with a food-safe clear glaze.

### Base Coat or Wash Colors

| | |
|---|---|
| 6600 Best Black | 10 % |
| 6339 Royal Blue | 5–10 % |
| 6069 Dark Coral | 35 % |

### Accent Slips

| | |
|---|---|
| 6129 Golden Ambrosia | 30 % |
| 6485 Titanium Yellow | 20 % |
| 6024 Orange | 30 % |
| 6236 Chartreuse | 50 % |
| 6027 Tangerine | 15 % |
| 6211 Pea Green | 50 % |
| 6288 Turquoise | 50 % |
| 6242 Bermuda | 10 % |
| 6069 Dark Coral | 35 % |
| 6122 Cedar | 25 % |
| 6304 Violet | 60 % |
| K5997 Cherry Red* | 30 % |
| 27496 Persimmon Red (Cerdec)* | 30 % |

* inclusion pigments

### Kate the Younger Clear Glaze

Cone 6

| | |
|---|---|
| Ferro Frit 3195 | 70 % |
| EPK Kaolin | 8 |
| Wollastonite | 10 |
| Silica | 12 |
| | 100 % |
| Add: Bentonite | 2 % |

From Richard Burkett. Use over colored slips. Shiny, resistant to crazing, cool slowly.