rare earths at cone 6

by Ryan Coppage, PhD

Eventually, we get a little tired of the standard glaze colors that are out there, and sometimes we just need more variety. Glazes using rare earth metals are available at high-fire temperatures and conditions, but that isn't viable for those of us with more humble facilities.

Defining the Terms

Dichroic: A dichroic substance is one that changes colors in various light sources–not necessarily in different polarizations of light.

Fluorescent Light: Primarily on the blue-sided light spectrum, though we perceive it as yellow-white. Despite this perception, most of the intensity of the light profile exists on the blue (400-520 nm) side of the spectrum (CFL, warehouse lighting, and halogen street lamps).

Full Spectrum Light: Contains either a continuum or single bands of light throughout the entire spectrum, creating the most full light profile (newer LEDs and natural sunlight).

Incandescent Light: Primarily on the red-sided light spectrum, though we perceive it as yellow. Despite this perception, most of the intensity of the light profile exists on the red (550–700 nm) side of the spectrum (refrigerator bulbs or sodium street lamps).

Rare Earth Metal: These elements are found in the lanthanide row of the periodic table, are rarer than others, and require some specialized processing for their purification. Unfortunately, they're also a little more expensive, costing \$60–80 per pound; however, they provide very unique color profiles and one has dichroic effects.

Rare Earth Metals

There are a variety of rare earth metals—28 of them in the lanthanides and actinides, to be exact—and many are either too expensive or radioactive, to incorporate into a glaze. The actinides are all radioactive, as elements after bismuth tend to be. Their nuclei are so large that the overwhelming number of protons and positive charges are not stable, blasting them apart into smaller-sized elements. Fortunately, most of the lanthanides are safe—even safer than copper, with a lower acute toxicity. They possess electrons in both the f and d orbitals that allow for some very unique color events—different from all of the transition metals that are traditionally used for ceramic glaze color.

The three rare earth metals that produce significant visible color are neodymium, erbium, and praseodymium. These have been shown to have intense color results in high-temperature firings, but have not been widely adapted for cone 6 oxidation. Since these are somewhat pastel at high metal loading (high percentages for metallic colorants), they are considered weaker colorants than the traditional transition metal colorants. This higher metal loading in a glaze base warrants mindfulness of cost as a function of that higher loading. While neodymium is reported to be sufficiently color-rich at 4–6%, the dichroic effect is more suitably strong at 7–8%. Praseodymium has a sufficient pastel green color at 7.5% and erbium is a soft rose pink at 8–10% loading.

Rare Earth Metal Glazes

There are three main glaze bases covered in this article. Two are adapted cone 6 celadon bases that assist with stabilizing the density of the rare earth metals put into them. In addition to those bases, I would recommend adding 0.05% CMC gum to the Nucular Green glaze to prevent settling. The Sorority Pink glaze possesses a significant amount of EPK, which is inhibitive of settling. Additionally, the base glaze stabilizes little bubbles within it, much akin to Ron Roy's 20's base; however, this recipe uses only the simplest of ingredients, which is more learning-effective for beginning students with respect to understanding glaze design from raw material components, and omits the need for purchasing specialized frits or wollastonite.

While any of the glaze bases can have one of the rare earth metal oxide colorants added to it, like the tiles glazed with the Bubble Base Glaze in (1) (which is the base recipe listed for Sorority Pink on page 58), each base was tuned to complement its colorant. The WTF Purple glaze is fully translucent with heavier crazing, to accentuate the dichroic effects. Sorority Pink is a softer/more muted pink in a high EPK kaolin base that does not show crazing on porcelain. Finally, the Nucular Green has some opacity/satin character, which complements the neon green color and feel of the cups (2). If erbium is used in either of the other bases, especially the neodymium base, it comes out as an electric candy pink and not a soft rose pink. Notably, the WTF Purple glaze is named after the exclamation that most people make as they transition across various light sources and observe color shifts in the glaze.

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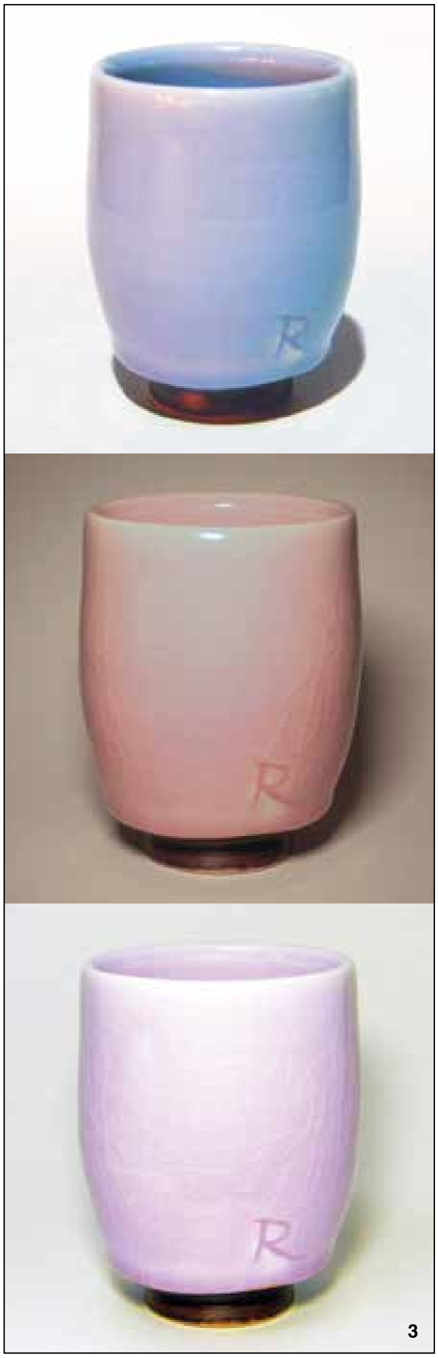
Dichroic Effects

Dichroic effects are somewhat rare in gemstones, but always elicit a smile when observed or held in a hand as the color change transpires. Neodymium is notorious for possessing dichroic



1 Test tiles with Bubble Base glaze. Colorant additions from Left to right: Neodymium Oxide, erbium oxide, and praseodymium oxide. **2** From left to right: A yunomi with WTF Purple glaze, a 7% neodymium oxide glaze; a yunomi with Sorority Pink glaze, an 8% erbium oxide glaze; a yunomi with Nucular Green glaze, a 7.5% praseodymium oxide glaze. **3** A yunomi with WTF Purple glaze photographed under three different light sources. From top to bottom: halogen light bulb, incandescent light bulb, and LED light bulb. All yunomi prepared with cone-6 Laguna Frost porcelain and fired to cone 6 in oxidation.

properties in glass, such that the development of a dichroic glaze is not unreasonable. To explain dichroics, I should communicate that the glaze is not actually changing in any way; the quality of light striking the glaze is changing and we can note that by watching the color change in the dichroic glaze. Blue-heavy lights like CFL bulbs, fluorescent bulbs, or halogen street lamps are mostly on the blue side of the spectrum and will cause neodymium to appear a soft to vibrant blue. Incandescent sources and sodium street lamps produce light that is mostly on the red side of the spectrum, thus one would primarily see only a pink/red glaze from the light reflected back. Full-spectrum sources, like some LEDs and natural sunlight, simultaneously reflect back both red and blue colors, thus we see lavender. In (3), a single yunomi has been exposed to halogen, incandescent, and LED lights, showing the three color extremes for neodymium glazes.

To this end, rare earth metals and new color profiles can be used at cone 6 in oxidation under more facile conditions and in lower budget kiln firings. As a series of addendum notes, I would suggest only using these glazes on the whitest of cone 6 porcelains, as iron content diminishes the dichroic properties. Avoid stoneware, iron-bearing clays, and contamination with iron-containing glazes.

The development of these glazes was inspired, requested, and sponsored by Ernestine Sitkiewicz at the Visual Arts Center of Richmond, Virginia.

the author *Ryan Coppage is currently Chemistry Faculty at the University of Richmond. He teaches a Japanese Ceramics and Glaze Design class at the Visual Arts Center of Richmond and still makes far too many pots. www.ryancoppage.com.*

WTF PURPLE
Cone 6 Oxidation

Gerstley Borate	15.5 %
Whiting	14.5
Nepheline Syenite	45.3
Grolleg Kaolin	5.0
Silica	19.7
	100.0 %
Add: Neodymium Oxide	7.0 %

This is an adapted cone-6 celadon base. It is fully translucent with heavier crazing, accentuating the dichroic effect of the neodymium oxide. If a glaze with neodymium is fired in reduction, it loses its dichroic properties, and the color will be a pale pastel blue.

BUBBLE BASE GLAZE (1)
Cone 6 Oxidation

Gerstley Borate	15.7 %
Whiting	11.3
Talc	6.1
Nepheline Syenite	26.2
EPK Kaolin	17.4
Silica	23.3
	100.0 %

For Sorority Pink:
Add: Erbium Oxide . . . . 8.0 %

A high EPK kaolin base that does not show crazing on porcelain.

NUCULAR GREEN
Cone 6 Oxidation

Gerstley Borate	14.2 %
Whiting	11.7
Nepheline Syenite	50.6
Grolleg Kaolin	5.0
Silica	18.5
	100.0 %
Add: Praseodymium. Oxide	7.5 %

Add 0.05% CMC gum can be added to this glaze to help prevent it from settling. This glaze has some opacity/ satin character.

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