The Effects of Kiln Atmosphere on Glaze Color and Texture

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Abstract.

This experiment studies the effects of the chemical colorants, red iron oxide (Fe_2O_3), copper carbonate ($CuCO_3$), cobalt carbonate ($CoCO_3$), black nickel oxide (Ni_2O_3), titanium dioxide (TiO_2), and rutile, an iron contaminated titanium mineral, in five different glaze bases. As a control group, each glaze base will be fired without added chemical colorants. These glazes are then fired to pyrometric equivalent cone 10 (2340˚F). Pyrometric cones, which measure heat (a function of temperature over time), are standard use in studio ceramics. Each glaze will be fired in three different kiln atmospheres: reduction, oxidation, and reduction with the addition of sodium carbonate, or soda ash (Na_2CO_3). A natural gas fueled kiln will be in each case, with alterations made to fuel:air ratios to create reduction or oxidation atmospheres. A natural gas kiln will also be used in the firing implementing the soda ash, which will be introduced into the kiln at 2300˚F.

The expected results include a variation of color and surface in the different kiln atmospheres. The reduction with soda ash atmosphere is expected to show the greatest variation in texture due to the addition of this vaporized chemical, which will unevenly coat the ceramic tiles in places and melt the glaze, adding areas of glossy surface and color variation. While the oxidation environment will show differences in color variation in comparison to the reduction atmosphere, especially within the glazes containing the addition of copper carbonate $CuCO_3$.

Test results from each group will be displayed for visual and tactile inspection.

Introduction

Many ceramic artists develop a palette of surface colors and textures by engaging in glaze testing and formulation research. This research is done to identify and create specific properties for the ceramic surface that are an integral part of the artist's conceptual ideas. Some people may ask why this is necessary since there are thousands of commercial glazes pre-tested and available for purchase. The answer is very simple. Those commercial glazes are designed for people who have very specific needs or a conceptual idea that revolves around a specific surface or color that is obvious and available to everyone. Many artists develop their ideas around a combination of forms and surfaces that are interesting and unique or have a historical significance to their work in the contemporary world. Another reason for the importance of glaze testing is the variation in chemical composition of glaze materials. Materials mined in different parts of the world or in different batches from the same location can vary in chemical composition and therefore may produce inconsistent results; testing is a necessary and ongoing process to maintain consistent results once they are obtained. The research done in this study is aimed at finding the combination of color and texture that create flesh tones, yellows, oranges, blues, browns, and pinks, where the human component is suggested without duplicating skin. These qualities are desired to augment my conceptual ideas of haptic space and represent the sensuous texture of skin in the same nonspecific manner as the surface of the vessel.

Experiment

This experiment studies the effects of the chemical colorants, red iron oxide (Fe_2O_3), copper carbonate ($CuCO_3$), cobalt carbonate ($CoCO_3$), black nickel oxide (Ni_2O_3), titanium dioxide (TiO_2), and rutile, an iron contaminated titanium mineral, in five different glaze bases [see tables 1,2,3,4,5,6]. As a control group, each glaze base will be fired without added chemical colorants. These glazes are then fired to pyrometric equivalent cone 10 (2340˚F). Pyrometric cones, which measure heat (a function of temperature over time), are standard use in studio ceramics. Each glaze will be fired in three different kiln atmospheres: reduction, oxidation, and reduction with the addition of sodium carbonate, or soda ash (Na_2CO_3). A natural gas fueled kiln will be used in each case, with alterations made to fuel:air ratios to create reduction or oxidation atmospheres. A natural gas kiln will also be used in the firing implementing the soda ash, which will be introduced into the kiln at 2300˚F.

Table: 1
Base 1

Materials	Grams %
Custer Feldspar	56.8
Dolomite	13.6
Whiting	10.6
Zinc Oxide	3
EPK	1

Table: 2
Base 2

Materials	Grams %
Cornwall Stone	46
Whiting	34
EPK	20

Table: 3
Base 3

Materials	Grams
Bone Ash	5
Dolomite	30
Kona F-4	40
EPK	25

Table: 4
Base 4

Materials	Grams
Wollastonite	22.5
Custer Feldspar	56.8
Strontium	12.5
EPK	1.5

Table: 5
Base 5

Materials	Grams
Kona F-4	44
Whiting	11
Silica	22
Talc	22

Table: 6
Chemical Colorant Groups

	1A Fe_2O_3 %	2B $CuCO_3$ %	3C $CoCO_3$ %	4D Ni_2O_3 %	5E TiO_2 %	6F Rutile %
Base 1	4	4	1	2	8	3
Base 2	4	4	2	2	6	8
Base 3	3	2	1	2	10	6
Base 4	5	2	1	2	8	8
Base 5	2	2	0.5	2	8	10

Results

Results demonstrated a range of variations in expected colors for the six colorants. Results were much more predictable in the reduction and oxidation atmospheres. In the reduction atmosphere with the addition of soda ash, results were usually similar to the reduction group, the general difference being a darker color and a wider range of surface variation within each tile. Glazes with iron displayed shades of brown in oxidation and greens in reduction. Copper, as noted earlier, produced the widest range of color from shades of red to pink in reduction with the exception of the base 3 group, which displayed mottled green and rust colors. In the oxidation atmosphere copper produced a variety of greens. Cobalt is a fairly strong colorant and turns shades of blue to violet in all atmospheres. Nickel produced grays and greens in reduction and browns and vivid greens in oxidation. Titanium revealed whites and grays in all atmospheres with the exception of the base 3 group, which were yellows. The rutile colorant exhibited peach to shades of tan in reduction and oxidation.

Discussion

Percentages for the colorants were chosen by prior experience from prior testing and available information regarding glaze material recommendations. All of the tests done in oxidation produced brighter, more vivid colors than their reduction and reduction soda counterparts. However, in the oxidation group, two noted differences occurred in bases 3 and 5. With the addition of Nickel, a bright lime green color was produced. This differs drastically from the light brown present in base 1 and the dark browns in groups 2 and 4. The materials used in base 3 and 5 that are related are: Dolomite and talc are sources of Magnesium Oxide MgO, whiting is a source of Calcium Oxide CaO but is usually contains some dolomite as a contaminant, bone ash is a triCalcium Phosphate that contains CaO and EPK is high in Silica. Because these base glazes have similarities in chemical composition similar results could occur. Further research is necessary to determine this inconsistent result within the nickel colorant groups.

As expected, there were darker shades of color with an interesting mottled variation in both the reduction and soda reduction groups.

Conclusions

The goal of this research was to find the combination of color and texture that create flesh tones, yellows, oranges, blues, browns, and pinks, where the human component is suggested without duplicating skin. The results provided positive significant results that consist of glaze differences and similarities consistent with these goals. The base 4 group did not supply any of the satin sheen or texture desired and the gloss surface is pitted and bubbled. Overall Base groups 1,2,3, and 5 warrant further testing for a full range of color variation.