A Changing Recipe for Engobe

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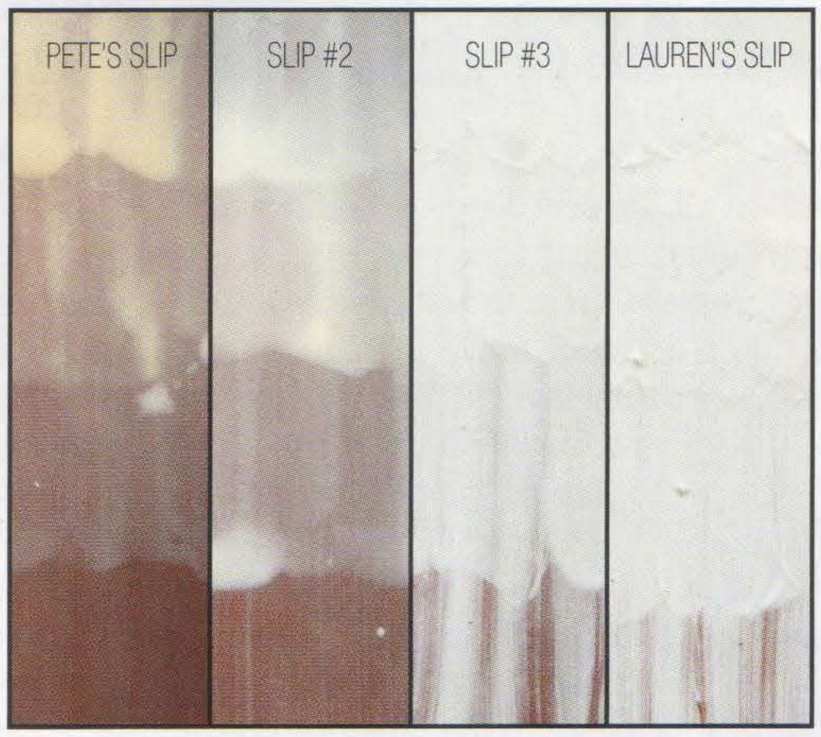
Things change. Of course we all know that this is true in life, and any of us who have been around ceramics for any time at all certainly know this. Every aspect of a raw material (color, particle size, chemical analysis, etc.) can change, either abruptly or over time, and materials can simply disappear altogether. Still, some of us can forget this obvious bit of wisdom and continue mixing up the same old recipes, assuming that it (the clay body, slip, glaze, etc.) will always be the same.

Last semester, I taught a glaze formulation course, and one of my students, Lauren Karle, decided to do her final project on low-fire slips. (As an aside, when we say "slip" in ceramics, we could be talking about a mixture as simple as a clay mixed with water, but most of the time we're actually talking about an "engobe," a mixture of clays, fluxes, fillers, colorants, and opacifiers. In this article, I'm actually talking about a white engobe, but I may slip and say slip, since this is what most of us call it).

She tested a number of low-fire slip recipes, including the one we use in all our beginning, undergraduate classes. This recipe is one that I developed about 25 years ago, and that we've used in our undergraduate program, unchanged, for the past 15 years. It was the result of a lot of testing (way back when), and has always seemed to be very forgiving and dependable. So when Lauren fired her tests, I was a bit surprised (and chagrined) to find out that this recipe wasn't very white, and it had a bad habit of causing the flat tiles to warp, with the slip side bulging upward in the firing. The other recipes she tested were whiter, more opaque, and none of them caused that odd warping.



Here's the class recipe:

Pete's White Slip
Cone 05-03 Oxidation

KT 1-4 Ball Clay	40%
Wollastonite	40
Nepheline Syenite	10
Silica	10
TOTAL	100%

I had Lauren try adding 10% Zircopax (an opacifier) to the slip, which did make it a bit whiter and a bit more opaque, but it still wasn't as white or opaque as the other recipes, and the Zircopax didn't affect the warping.

The "fit" of our slip to our clay body is excellent: it doesn't peel or crack, and it can be applied at any stage from wet to bisque (it needs to be applied thinly to bisque). Similarly, its glaze fit was good: glazes applied over the slip didn't craze, dunt, or shiver. Moisture expansion was nil: the glazes that were applied over the slip didn't craze after being soaked in water for 24 hours.

But there were three problems: it wasn't white (more of a light beige), it wasn't opaque (more translucent, really), and it caused that odd warping on a flat tile. By contrast, several of the other recipes that Lauren tested were very bright, very white, and very opaque. The surface of the clear glaze was almost flawless on top of them. Here are a couple of the other recipes she tested:

White Slip #2
Cone 04 to 10

EPK	25%
Ball Clay	25%
Silica	25%
Kona F-4 Feldspar	25%
TOTAL	100%

White Slip #3
Cone 04 to 9

Tile # 6 Clay	34%
OM 4 Ball Clay	20%
Custer Feldspar	27%
Silica	19%
TOTAL	100%
add:	
Zircopax	8%

Looking at both of these successful recipes, you can see that they are very similar: both use a blend of light-firing clays (kaolin and ball clay), some silica, and a fluxing material (feldspar) to help the slip mature. However, neither of them contains a flux that is active at earthenware temperatures. A soda feldspar (like Kona F-4) begins to actively melt at mid-range temperatures (cone 5-7), and Custer Feldspar is a potash 'spar,' most active at cone 7 and above. Usually, if you want a clay body (or engobe) to mature at cone 04, you would use as the primary flux an alkaline earth source like talc (a magnesium silicate) or wollastonite (a calcium silicate), and then add an alkaline flux (like feldspar) as a secondary flux.

So why would it matter if the slip doesn't contain the fluxes we normally use at earthenware temperatures? After all, both of these slips were beautiful when fired. What I would be concerned about is a problem called "moisture expansion" (I alluded to this in a previous paragraph). When a

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clay body is underfired, a glaze might initially fit the body, so everything will look, feel, and even "sound" right. But underfired bodies tend to expand when they absorb water—like a dry sponge placed in a bucket of water—and when they expand, they stretch the glaze, causing delayed crazing. That's why we sometimes see glazes begin to craze as of days, weeks, or even months after a pot leaves the firing. Of course a slip is a very thin layer, and during the firing it is effectively made even thinner by the glaze/slip interface at its upper edge, and the slip/clay interface at the lower edge. So I wasn't entirely sure it would react in the same way when it was exposed to water.

Lauren put these tiles in a bucket of water overnight, and the next day they were crazed, so moisture expansion is definitely a potential issue. Why just "potential"? With an object that won't (or can't) be used for food or drink, delayed crazing isn't as important; but for utilitarian pottery, delayed crazing is probably even worse than immediate crazing. What potter would want a customer returning a vase with the news that it had leaked, and ruined the top of an antique sideboard?

I also suspect that any glaze that's applied over an underfired slip would probably be more prone to chipping. We've all felt how soft bisque-fired porcelain is, and these slips, at cone 04, are simply bisqueware. I would be very concerned about the ability of these slips to stand up to the banging around that even our "nice" pots endure.

"When I see a claim like 'cone 04 to 10,' I tend to place it in the same category as 'one size fits all' panty hose."

In all honesty, I expected this would be the outcome just from reading the title of the recipe. It's rare to find anything ceramic that has a useful range of more than about 5 cones, so when I see a claim like "cone 04 to 10," I tend to place it in the same category as "one size fits all" panty hose.

That left us with the task of combining the best traits of all these slip recipes. Lauren did a variety of substitution tests within our original recipe and the results were quite interesting. Using a whiter-firing clay (like a kaolin) did make a recipe marginally whiter, but a slip that is formulated with a wide-particle-size, blended ball clay (like KT 1-4 or Spinks C&C) was more forgiving in application, even if just a bit more cream-colored at cone 04. The big difference in color came when Lauren substituted talc (Amtal C-92, a Texas talc) for wollastonite: the slip suddenly became much whiter and opaque, while the glaze fit was still good and a 24-hour soak in water didn't cause any problems. It actually seems a bit odd, because unfired Amtel talc is gray, so the wet slip itself is quite gray in color. Still, it fires white, and with talc substituted for wollastonite the warping disappeared.

I'm not sure what has happened with wollastonite over the past 25 years. Perhaps I'm just buying a different brand or grade than I did long ago, but the switch to talc appears to be all that's necessary to fix the problems.

If you're wondering why we include the other ingredients (nepheline syenite and quartz), it's because they each play a role in the fired qualities of the slip. Slips that contain a large amount of calcium or magnesium occasionally have a tendency to cause shivering, a fired condition in which

the glaze flakes off the body in sharp little fragments: sometimes just at the edges, and sometimes all over. Ironically, this seems to happen more often with objects that we care most about and fire (and cool) very slowly. This tendency can be controlled by including some alkali (sodium or potassium oxide) in the recipe. Nepheline syenite contains both sodium and potassium and is relatively insoluble, which makes it a good choice for this. The silica is included because it helps prevent crazing, and its non-plastic characteristic helps keep the wet slip from shrinking too much as it dries. This recipe contains a smaller percentage of quartz than the other recipes we looked at, but that's because the talc partially fulfills the qualities provided by the quartz.

Lauren could have quit there, but we decided to try one more thing. Many years ago I did some testing with Plastic Vitrox (also known as PV Clay), a California material that has been used in a lot of clay bodies, both low- and high-fire. If you look at a chemical analysis for it, it looks like a high-fire flux, and indeed, it's used as that in a number of popular commercial clay bodies. On the other hand, many potters have also used it as a flux in white earthenware bodies. On paper, this makes no sense to me at all, but somehow it really does work. I've tested it in the past, and Lauren tried it again this time, and it worked in substitution for some or all of the talc. I have mixed feelings about this: I'm reminded of the point in one of the Harry Potter novels when Harry and his friends were told "Never trust anything that can think for itself if you can't see where it keeps its brain." On the one hand, Plastic Vitrox contains less magnesium than talc, and magnesium can alter or destroy some colors from commercial stains, so it has that advantage. On the other hand, I'm not sure I trust an effect that I can't understand.

In the end, Lauren decided to go half way, and split the talc with Plastic Vitrox. In initial use this slip seems to be working out quite well. Here's the final recipe:

Lauren Karle's White Slip

Cone 05-03

KT 1-4 Ball clay	40%
Amtel C-92 Talc	20%
Plastic Vitrox	20%
Nepheline Syenite	10%
Silica ("quartz, flint")	10%
TOTAL	100%

The recipe could be used alone as a base for colors, or with the addition of Zircopax (10% or so) it is whiter and more opaque. Kaolin could be substituted for up to half of the ball clay if a whiter surface is desired.