Super-Refined Terra Sigillata

Vince Pitelka, ©2019

Introduction

Traditionally, the primary objective of terra sigillata refined slip coatings is to get a high satin gloss without a glaze, using simple, time-effective polishing methods. There is some misunderstanding about the translation of the term, and many people believe that it means "clay with a sealed surface." The translation is actually closer to "clay with little images," referring to the finely-detailed raised-relief imagery on Roman Arretine ware. Arretine ware always featured a terra sigillata finish and represented the pinnacle of Roman ceramics, and the term "terra sigillata" evolved to apply to the refined slip itself used on any sort of ware.

Super-refined polishing slips were first used in the Middle East at least 1000 BC, and reached a pinnacle of aesthetics and technical accomplishment with the terra sigillatas used on Greek and Roman pottery. The purity of terra sigillata is perhaps most celebrated on fine Roman Arretine wares, with the monochromatic red high-gloss coating emphasizing the complex relief decoration mentioned above. But like so many innovations of the Romans, the technology was completely lost in the early middle ages.

Most of the popular published terra sigillata recipes do not separate and eliminate the large particles adequately, and the product is not a true terra sig. In the late 1980s I began researching terra sigillatas in conjunction with the Ancient Clay classes and workshops I developed at UMass-Amherst. First experiments were derived from standard recipes in ceramics books and magazines and the results were unsatisfactory. I wanted to achieve what I saw on ancient Roman pottery, so I went to the UMass-Amherst library and researched terra sigillata.

In the late 19th century, German ceramic chemist Henrich Schumann was seeking low-cost coatings for sanitary sewer pipe. That doesn't sound very romantic, but it drove him to rediscover the secret of terra sigillata. Schumann was fascinated by the surfaces on Roman pottery, and conducted microscopic cross section analysis of shards. He determined that terra sigillata is a very thin coating of refined slip composed of only the finest clay platelets. Through subsequent experimentation, he was able to reproduced high-quality terra sig surfaces. Schumann's findings guided me, and experiments conducted with students Heather Shadron and Rob Williamson at UMass-Amherst led to the specific techniques outlined below.

Why Does it Work?

In order to understand how terra sig works, you must grasp the sub-microscopic size of clay particles. Pure clay is composed of kaolinite crystals in particles called platelets. The average size of a clay platelet is less than two microns, and a micron is 1/1000 of a millimeter. If you do the calculations you will see that there are over 2,000,000,000,000 (two trillion) clay platelets in one cubic inch of clay. In comparison, fine white silica sand such as we add to claybodies is generally about 80-mesh, which means that it has passed through a screen having 80 openings per inch. The openings in a standard 80-mesh glaze sieve are about .007 in diameter, and thus it would take 125 grains of sand lined up in a row to make one inch. If you do the math, you'll see that you get about 2,000,000 grains of sand per cubic inch. So, a grain of 80-mesh sand is 1,000,000 times larger than the average clay platelet.

To anyone new to terra sig, it seems magical when you polish the surface for the first time. Most experienced clay workers have discovered that almost any hard-leather-hard clay surface can be rubbed to create a soft gloss, or burnished to create a high shine, but the latter involves a lot of work. Kaolinite crystals are thin, flat, and reflective on the surface. In normally-worked clay, the alignment of particles is random on the surface of the ware, and thus there is little or no reflective quality. But if you do anything to cause the platelets to lay down flat, the amount of reflection increases. Processing terra sig according to the instructions below eliminates all but the very finest fraction of particles, and the ultra-fine platelets that remain will naturally lay flat on the surface, producing some degree of reflection. Any compression through polishing with a piece of chamois or plastic film or even with a fingertip will increase the fraction of platelets lying flat on the surface, increasing the reflected light and our perception of a shiny surface.

What's the Difference Between Polishing and Burnishing?

Polishing refers to any process that produces a shine on the clay surface. This might be achieved by rubbing the clay with your fingertips, a soft brush, a piece of chamois, a soft cloth, or a piece of plastic film, but polishing also includes the process known as burnishing. Burnishing is just one type of polishing, and specifically involves compressing the surface by rubbing with a hard, smooth, unyielding object, like a polished rock or the back of a spoon. Burnishing processes are also found in metals, leather, wood, and fabrics, and they all fit the definition above. When you burnish a very-hard-leather-hard or re-moistened bone-dry clay surface, *all* of the clay platelets are forced to lay flat, while any coarse particles are pressed down into the surface, leaving a very smooth, reflective surface. As mentioned below, terra sig makes a good burnishing slip, but one of the reasons we go to all the trouble to make a proper terra sig is to get a polished surface without the labor-intensive process of burnishing.

Get an Appropriate Hydrometer

An appropriate hydrometer that measures ***specific gravity*** is required for this technique. A winemaker's hydrometer will not work, because it measures fluids lighter than water. Glaze

hydrometers that measures specific gravity will work, but they generally have a scale reading from 1.00 (the weight of water) to 2.00. That works well for thinner glaze suspensions but does not offer enough precision in the range needed for terra sig. Online laboratory supply sites offer appropriate hydrometers that measure specific gravity from 1.00 to 1.20, which is the ideal range for terra sig. Go to www.sargentwelch.com and enter WLS-42035-A in the search box to find a good hydrometer for this application. Be sure to specify the one with the specific gravity range from 1.000-1.220, exactly the range needed for terra sig. Note that hydrometers are extremely fragile. Get at least two, and never shake them while holding the thin end of the stem.

Selecting the Clay

You can make terra sig from almost any raw clay or mixed claybody, but the yield will depend on the average particle size. Finely divided air-floated clays such as Redart or Goldart and most ball clays give a high yield of sig. Coarser clays like kaolin and fireclay give less sig and a far greater fraction of settled coarse residue. Don't bother trying to make a sig from bentonite - it is too fine already and doesn't yield a good sig. Selection of the clay will usually depend on the desired color. See the section on "Firing Ranges and Natural Clay Colors Achieved with Terra Sig" for more information.

Some clays are so coarse as to give a very low yield of sig. If you have some compelling reason to choose a particular clay and find the yield of terra sig especially low, as is the case with some red stoneware clays, the raw clay can be ball-milled before incorporating in to the initial mixture. See the section on "Adding Coloring Oxides and Ceramic Stains" for more information on ball-milling.

Preparing the Deflocculant

The secret of refining a proper terra sigillata is to settle out all but the very finest particles. A ***deflocculant*** is a chemical additive that causes particles in aqueous suspension to repel one another, and it is a critical part of the terra sig process. Only a tiny amount of deflocculant is needed, and adding additional is counterproductive, so be very careful with your math and your measuring. ***Soda ash*** (sodium carbonate) and ***sodium silicate*** both work as deflocculants, but for reasons no one can explain, a combination of the two work best in terra sig.

The amount of deflocculant is figured as a percentage of the dry weight of clay to be used. To a small amount of hot water, add 0.25% (1/4 of 1%) soda ash (sodium carbonate) ***and*** 0.25% sodium silicate. A hand blender will make short work of dissolving the chemicals. The sodium silicate comes as a thick liquid, but just measure the weight as if it were a solid.

Measuring Specific Gravity with a Hydrometer

To measure specific gravity with a hydrometer, the liquid must be in a container tall enough to float the hydrometer. If your mixing container is not tall enough, pour some of the liquid into a

tall thin container. The most practical container for this application is a laboratory graduated cylinder. Go to an online laboratory supply site and purchase a plastic 250 ml. graduated cylinder. Lower the heavy end of the hydrometer carefully into the liquid until it floats on its own, and read the scale exactly where the hydrometer tube meets the surface of the liquid. For greatest accuracy, observe the ***meniscus***, the upward-curved edge of liquid where it meets an impermeable vertical surface. In this case, the meniscus is the point where the liquid naturally curves upward where it meets the hydrometer, and you want to observe the specific gravity at the upper edge of the meniscus. Do that consistently, and you will get consistent results.

Immediately before measuring the specific gravity with a hydrometer, always be sure to mix your terra sigillata thoroughly with a hand blender or drill-mounted impeller mixer. Particles will start settling quickly, especially in the initial mixture, and you must make sure that all particles are in suspension in order to get an accurate hydrometer reading.

Determining the Initial Mixture

For the time and trouble involved, and considering the low cost of raw clay, it is best to make a quantity of sig all at once. I never make less than five gallons of initial mixture. After settling, siphoning, and concentrating, that will yield about a half-gallon of super-refined Redart terra sig, or about two gallons of ball clay sig. A near-full five-gallon bucket of initial mixture will take about 14 lbs. of Redart, Goldart, kaolin, fire clay, or any dry claybody, or about 11 lbs. of ball clay.

Add the dissolved deflocculant mix to cold water, starting with a quart of cold water for every two pounds of dry clay to be used. Add the dry clay, blending with a drill-mounted impeller mixer. When all the dry clay is mixed in, add more cold water, mixing well, and check frequently with the hydrometer until the specific gravity reading is 1.20 for most clays, and 1.15 for ball clays. If you are mixing in a full five-gallon bucket, float the hydrometer right in the bucket. If mixing smaller quantities, you will need a graduated cylinder or other appropriate tall, narrow container as mentioned above.

Settling the Initial Mixture

As soon as you've finished blending the initial mixture, note the time, and *place the container on a surface at least 2' off the floor and leave it completely undisturbed for 20 hours*. It must be in a location where you can siphon from it, and it will be a great advantage to have the bottom of the container at least two to three feet above the floor. Once you have finished the initial mixing and have placed the container in an appropriate location, don't do anything to agitate the mixture.

Don't be careless about this. Do not move or agitate the container in any way during the 20-hour settling time, or during the siphoning process outlined below. If you even move the

bucket, you have agitated the mix. Consistency in method and timing is critically important in making good terra sig. If you accidentally agitate the mixture or are forced to move it for some reason, or if you let the mixture stand for longer than 20 hours, thoroughly mix it again with a drill-mounted impeller mixer, note the time, and start the 20 hours settling period again.

Why 20 Hours?

The 20-hour settling time may seem arbitrary, but it's not. I am grateful to student Rob Williamson at UMass for helping to determine the ideal settling time. There are several forces at work in a deflocculated aqueous particle suspension. The deflocculant introduces same electrical charges to the particles, causing them to repel one another and stay in suspension longer. Also, the ever-present atomic vibration causes particles in liquids to naturally disperse. Working against these forces is gravity, causing particles to settle out. At 20 hours, in a deflocculated slip mixed to the correct specific gravity, the forces of gravity will have caused all the heavier particles to settle out, while atomic vibration and the repelling forces caused by deflocculation keep the finest particles (generally those less than one micron - 1/1000 of a mm) in suspension.

The 20-hour settling time is a compromise based on average clay particle distribution in airfloated clays. For a claybody containing a finer distribution of particle sizes, such as a ball clay, a longer settling time might be more effective. For any raw clay, a longer settling time might produce an even finer terra sig, but would also produce a lower yield. This is an area ripe for experimentation.

Decanting the Terra Sig: Get a Proper Racking Tube

The essential tool for decanting the dilute terra sig is a winemaker's siphon, referred to in the winemaking industry as a ***racking tube*** or ***racking cane***. You can get one on amazon or from any supplier of winemaking equipment. Note that in some cases the racking tube comes with attached flexible tubing, while in other cases the tubing must be ordered separately.

An appropriate racking tube features a "J"-shaped rigid plastic tube attached to a length of flexible plastic tubing. An important feature of a good racking tube is the ***diversion cap*** on the suction end of the rigid tube. This allows fluid to enter above the cap rather than below, and offers real advantages in siphoning terra sig. As you gently probe downwards with the rigid tube, the objective is to sense the increased density of heavier sediments before the siphon starts to pick up those sediments, thus avoiding contaminating the terra sig. The diversion cap makes this much more feasible.

Siphoning Off the Dilute Terra Sig

After the settling period, the upper part of the mix is a very dilute terra sigillata, and must be carefully siphoned off, avoiding the heavier sediments lower down in the container. This is a touchy process and must be done properly with the right equipment. While siphoning, do not

discard any liquid at the top. Some clays will give a seemingly transparent layer of water at the top, but this layer contains some of the very finest particles. Siphon off the transparent layer (if any) and keep siphoning until you come to heaver sediments in the lower portion of the container.

Start the siphon with the diversion cap just barely immersed in the settled mix. *As mentioned above, do not agitate this container or the settled mix at all.* Once the siphoning is started, gently lower the tip of the siphon tube into the mixture as the thin liquid is siphoned off, keeping the diversion tip just below the surface. The diversion cap will occasionally suck a bit of air, but that hurts nothing, and tells you that the tip is close to the surface. If it sucks too much air the siphoning action will cease, and you'll have to restart it. You will quickly get a feeling for this.

With some airfloated clays such as Redart, the heavier sediments will form a distinct layer with a fairly hard surface, and you will feel that layer with the tip of the diversion cap. As soon as this happens, lift the siphon tube and stop siphoning immediately. Don't risk picking up any of the heavier sediments.

With some very fine-particle clays that don't contain a significant fraction of larger particles, you might never feel a distinctly heavier layer after 20 hours of settling. In that case, let the suction tube suck a little air every few seconds, and note the change when the siphon naturally begins to suck more air, indicating that the mixture is getting thicker. Once again, as soon as this happens, lift the siphon tube and stop siphoning immediately.

With most ball clays, the particle size is so small and consistent that you never will sense a heavier layer of sediment at all. In that case, just siphon off the top half of the mixture and discard the rest, and you will get a good terra sig. That may seem inexact, but there doesn't seem to be any other choice, and that bottom half does contain the heavier particles. As instructed above, when making ball clay terra sig, start with a thinner 1.15 specific gravity initial mixture in order to encourage the coarsest particles to settle, so even if you are not able to identify thicker sediments in the lower portion of the vessel, you can be sure they are there. Don't try to siphon off more than half. You'll still get a very high yield, and it just isn't worth risking contaminating the sig.

With most clays, the residue of heavier sediment left in the bottom of the container represents most of the weight of what you started out with, but I have never tried to do anything with that residue. Raw clay is cheap, while terra sig is very valuable based on your time invested. The residue already has the finest particles removed, and thus is relatively non-plastic. I discard it, but you may find a good use for it.

Concentrating the Thin Sig by Evaporation

Since the initial mixture is either 1.20 or 1.15 specific gravity, and most of the heavy particles are settled out and discarded, the siphoned mixture will be extremely thin and relatively unusable. The next challenge is to concentrate the sig back to a usable density by evaporating water. This can be done by natural evaporation in any wide, low container will work, such as one of those broad dish-shaped plastic snow sleds, an automotive oil-change pan, or a very large round or rectangular cake pan. Protect the concentrating sig from contamination by large particles, but don't put a cloth over it, because that will severely retard evaporation. Don't worry about bugs or the very fine particles of dust that float in the air. Those particles won't hurt the sig, and the bugs can be skimmed off.

Accelerating Concentration of the Thin Sig by Heat

You can concentrate terra sig with heat, but don't attempt it on direct heat, like a stove burner or hotplate. The sig will solidify directly on the bottom of the pot and the metal will burn. Do not ever allow the sig to boil, because it will spatter and make a huge mess, and that is also an indication of excessive heat that can cause the sig to solidify as mentioned above and damage the container. I concentrate terra sig in a large metal mixing bowl, placed carefully-centered on the bottom shelf of a toploader electric kiln. It may be easier to place the empty bowl on the bottom shelf and then carefully fill it with a measuring cup, being very cautious to avoid splattering sig on the heating elements. In either case, turn off the circuit breaker feeding the kiln while you place or remove the metal container.

Leave the lid of the kiln fully open for the duration of concentrating. On a kiln-sitter kiln, set the bottom and middle elements on low overnight or until the sig is adequately concentrated. On a programmable kiln, set the kiln on slow-bisque with a 24-hour preheat and intercept it before the end of preheat. If it needs more time, shut it off and reset it for another 24-hour preheat. It will take longer whenever the humidity is high. Again, leave the lid of the kiln fully open for the duration of concentrating.

As another option, use a crock pot set on medium heat with the lid off. In either case, the rate of drying will depend on the atmospheric humidity and the amount of heat applied. It will take some experimentation to learn the ideal conditions.

Using the Sig as Soon as It has Concentrated

If you are in a rush to use the sig, watch it carefully, and when it has thickened considerably, scrape the thick accumulation loose and mix back into suspension with a whisk. Carefully add water to adjust the specific gravity as indicated below.

Storing the Sig in Dry Form

If you don't need the sig right away, let it dry completely, scrape it loose from the container, and store it in Ziploc bags until needed. You don't need to break it up further, because it will

slake down to slurry when it is immersed in water. Drying doesn't hurt the sig in any way. Twenty-four hours before you need to use the sig, place an appropriate amount in a container and cover with water one inch above the sig. Let it sit overnight, blend thoroughly with a hand-blender or drill-mounted impeller mixer (depending on the quantity), and then add more water, checking the consistency with the hydrometer to get the desired specific gravity.

Determining the Specific Gravity for Application

The finer the particle size in a clay or slip, the more water layers between particles, and the greater the drying shrinkage. Because of that, a terra sig must be mixed very thinly to work properly, but beyond that there are no hard and fast rules for the ideal consistency of sig for application. The thicker the sig, the less water introduced into the claybody, but the greater chance that the sig layer will develop stress during drying, causing it to crack and peel during drying or firing. The thinner the sig, the less chance it will crack and peel, but the more coats you will need, and thus more water introduced into the claybody, risking cracks in the ware. For most sigs and most application methods, I have had best results with a specific gravity of 1.15, and would not recommend using sig mixed thicker than that. This material simply does work well with a thicker suspension and thus thicker application layers, and most attempts to use a thicker suspension will result in cracking and peeling during drying, firing, or subsequent use. You will always get the best results with multiple thin layers of terra sig.

When and How to Apply the Terra Sig

Some people recommend applying sig to leather-hard clay, but in my experience that is a waste of time unless you are only interested in the color and natural soft satin sheen terra sig can give without polishing or burnishing. Because of the ultra-fine particle size, any dry sig layer is very dense, far more so if it has been polished. It has very little capacity for additional shrinkage, and none at all if it has been burnished. Even hard-leather-hard clay will shrink as it dries, and the sig coating will crinkle on a microscopic level, diminishing or ruining any shine.

I apply terra sig to bone dry clay, and get the best adhesion when the clay has been sanded. Since most of my terra sig use is in conjunction with the Ancient Clay workshops I teach, the pieces are usually sanded, as is the tradition among Southwestern Native Americans and many other cultures past and present that polish or burnish their wares. Always wear an appropriate P-100 respirator when sanding terra sig. I sand with 120-grit drywall sanding mesh, available on amazon or from any building materials supplier or home-improvement center.

If you do sand your wares, be sure to thoroughly wipe down all surfaces with a soft cloth such as tee-shirt material in order to remove all dust. If you neglect to do this, the paintbrush will carry the dust back to your sig container, contaminating the sig. If your wares feature complex relief surfaces, gently blow off the dust with compressed air, and whether sanding or using compressed air, wear a proper P-100 respirator. Go to my website (www.vincepitelka.com),

click on “Documents and Handouts” and check out the one on “Buying a Proper Respirator for Dust Protection.”

I apply terra sig with a wide, thick soft brush heavily loaded with sig, laying on flowing strokes, carefully avoiding drips. East Asian hake brushes work great. If the sig does drip down the surface, chase the drips with your brush. Don’t let the drips harden on the surface, and don’t ever let the piece sit in sig pooled at the base. I work my way around the piece, building up thin coats until I get an opaque surface that begins to conceal the finest details of texture, which will be obvious if the piece has been sanded. That’s still a very thin coat overall, but if you accumulate much more thickness, you are risking subsequent cracking and peeling of the sig coat.

If you wish to preserve some of the color and fine surface texture of the base clay surface, you can still achieve a good shine with an almost transparent coat, because the shine results from the ultra-fine clay platelets lying flat on the surface. Ultimately, it’s a matter of experience with your particular terra sig and base claybody. Experiment with the thinnest layer possible, and see if it meets your needs. Build up from there to see what you can get away with.

I have applied very thin coats of terra sig to bisqueware with adequate results, but it will never produce the level of shine or durability of surface achieved with a sig applied to bone dry clay. Terra sig applied thickly on bisqueware will almost always crack and peel upon drying or during or after firing.

Polishing the Sig Surface

As soon as you achieve the desired sig buildup, and the wetness has soaked in, you can polish the surface with a piece of grocery bag plastic stretched over your fingertips. The first time you do this, you won’t believe what happens. It is magical. Grocery bag plastic is harder and denser than other plastic bag material, and gives a better shine. Some people prefer to polish with soft flannel or tee-shirt material, very soft chamois, or a soft brush, but I have had best success with the grocery bag plastic. I get a glassy shine in one polish, after all coats of terra sig have been applied.

There’s no reason to polish between coats, but when you do polish, if you are not satisfied with the shine, go ahead and paint on more terra sig. The new coat disrupts the previous shine, achieving a good bond.

It is possible to burnish any re-moistened bone-dry clay surface, but burnishing usually gives more satisfactory results if some sort of refined slip has been applied to the base clay. A properly prepared terra sig makes an excellent burnishing slip, but if you rely entirely on the moisture introduced by the sig, burnishing must be completed in one sitting while the coating is still damp. Otherwise the surface will begin to flake and crack. To prevent this, especially with

larger forms, many potters apply the sig, allow the water to absorb, and then apply a thin smear-coat of lard or glycerin, allowing it to absorb before burnishing. The grease retards drying, giving you time to finish burnishing the piece.

Even though terra sig makes a good burnishing slip, it is not the ideal use of this medium. The whole point of this elaborate preparation process is to produce a thin slip medium that polishes beautifully and gives the unique terra sig shine, but without the labor-intensity of burnishing. After proper application of terra sigillata, the actual polishing process on a medium-sized pot using grocery bag plastic takes ten or fifteen minutes. A thorough burnishing job on the same pot takes several hours.

Firing Ranges and Natural Clay Colors Achieved with Terra Sig

All traditional polished terra sig surfaces were fired to temperatures within the lowfire range, but in this regard there is a significant difference between polished terra sig and a burnished surface. The whole point of a traditional terra sig is to achieve a high shine without the labor-intensive process of burnishing. A true burnished surface is far more compressed than polished terra sig and cannot be fired above cone 014. Beyond that, the compressed surface starts to shrink, and crinkles on a microscopic level, destroying the shine. A terra sig-coated surface polished by means other than burnishing can be usually fired to high low-fire temperatures, sometimes as high as cone 02, and the polish will remain intact. Above cone 02, as firing shrinkage increases, the shine will diminish. At higher temperatures, terra sigs can still give an appealing satin finish, but without the shine that characterizes classic terra sig wares.

The maximum temperature at which a terra sig retains any integrity to the original material depends on the clay used. At cone 014, Redart terra sig gives a bright brick-red-orange color. At cone 08 it gives a classic brick red, and at cone 02 it gives a red brown. At midrange and highfire temperatures, a Redart (or other earthenware clay) terra sig will fuse and become a glaze with no resemblance or connection to terra sig.

Stoneware clays like Goldart and most fire clays give an off-white color at low temperatures, and at midrange and highfire temperatures will produce a tan in oxidation and gray in reduction.

Ball clays generally give white at lowfire temperatures, and off-white or gray at highfire. Most kaolins produce white at all temperatures, but some will give a grayed eggshell white in reduction firing.

Red stoneware clays like Carbondale, Lizella, or Neuman red are often quite coarse and will give a very low yield of terra sig unless ball-milled before incorporation into the initial mix. Once that is done, they can give a good brick-red terra sig that will hold its color and satin (not gloss!) surface to highfire without fusing into a glaze.

Slip clays like Alberta, Barnard, or Blackbird are often too coarse to make a terra sig, but might respond well to ball milling.

For the purposes of blackware firing, a properly-made Redart sig produces a very dense coating, and gives a range of colors from brick red to jet-black, and any re-oxidized or protected spots be brown or brick red. Ball clay terra sig is slightly more porous, and in a blackware bonfiring can give intense jet-black, and any protected or re-oxidized spots will be gray or white.

Adding Coloring Oxides or Ceramic Stains - Using a Ball-Mill

I always work with pure clay terra sigs, because they give the best shine, and because I like the natural clay colors. Colored sigs are an appealing option, but some oxides and all commercial ceramic stains are coarsely ground and will diminish the potential for polishing the sig. Very finely divided oxides like copper carbonate or cobalt carbonate can be added in small quantities without significant loss of shine. When using other oxides, or when using fritted ceramic stains like Mason stains, you will need to ball-mill the mix. A commercially-made ball mill is a very expensive piece of equipment, but you can make do with a large horizontal-barrel-type rock-tumbler.

Such rock-tumblers generally have a rubber-lined tumbling container to reduce noise, but that means less abrasion when the grinding media tumble against the rubber, as compared to the heavy porcelain jar of a true studio ball-mill. That just means it takes quite a bit longer to accomplish the same thing with a rock tumbler. Fill the reservoir one third with quartz pebbles or glass marbles, and one third with thick, creamy-consistency terra sig with the oxides or stains added, leaving one third air space. Do not overfill the reservoir or the materials will not tumble properly.

If you purchase commercial grinding media to use in your ball-mill or rock-tumbler, get rounded grinding balls or pebbles. Cylindrical grinding media is intended for dry grinding. Ball-mill the sig mixture for at least 24 hours, thin a small amount to the desired consistency, and test it. If the colorants settle out quickly, or if it does not develop a good shine, it needs to be ball milled longer. This will require experimentation on your part, because it is outside my own area of experience. Ball-milling certainly helps, but just keep in mind that no matter how much you divide the particle size of added colorants, they will always be far coarser than clay platelets, and it is only the clay platelets that develop shine. No matter what, the more non-clay contaminants you add, the less shine you will achieve.

Using Terra Sig to Coat Feet and Lid Seats

From a philosophical point of view, I like "dry-footed" wares, where you can see and feel the unglazed clay on the foot of a vessel, and I like the feel of a snug-fitting clay-to-clay lid seat. I find no advantage in a glazed foot, especially on midrange and highfired ware, and I distinctly

dislike the sound and feel when you set it down on a hard surface like tile or stone. The same with the brittle, fragile sound and feel and fit of a glazed lid seat, and again, there is no advantage in it. However, some claybodies high in grog or sand can give unpleasantly rough surfaces on the exposed clay of a foot or lid seat, and you are certainly be justified in wanting a smoother surface. One solution is to coat those surfaces with terra sig made from the base claybody. That way, you still have the visual and tactile contrast of unglazed clay on the foot or lid seat, showing the claybody, but it will be smoother to the touch.

Slake down scrap claybody clay overnight in ample water and mix with a drill-mounted impeller mixer, adding more water to achieve the 1.2 specific gravity initial mixture. Don't worry about the presence of sand or grog, because those will be the first components to settle out in the initial mix.

If you do not use the base claybody, select a clay appropriate to the base claybody and the intended firing temperature. Remember, an earthenware clay slip will become a glaze at midrange and high-fire temperatures. Terra sigs made from stoneware clays like Goldart or from a ball clay or kaolin will work fine up to high-fire temperatures, and even then will still give a smoother surface than the base clay.

Using Terra Sig Under a Glaze

This may come as a surprise, because historically terra sig is always used alone, without a glaze, since the objective is usually the unique shine possible with a true terra sig. The clay-glaze interface is a site of considerable thermochemical activity, dependent on the firing temperature and the flux content of the glaze. The old aphorism "the glaze feeds off the body" is especially appropriate here. As a glaze fuses, it has considerable solvent effect on the surface of the clay, and some of the surface materials are dissolved into the glaze. That's why a celadon sometimes goes brown where applied thinly on an iron-bearing stoneware body – it incorporates additional iron from the body, pushing the celadon to the darker iron color.

Anyone who has done considerable slip decoration has experienced the effect where a very thin application of slip simply disappears, having been absorbed into the glaze. That's what happens with terra sig. However, like any liquid medium applied to dry greenware or to bisqueware, terra sig will settle more thickly in recesses and textural details, and thinly on high spots and flat areas. In the thicker areas, the glaze will not dissolve the terra sig coating, and it will have a localized effect on glaze color. This could be an advantage with almost any glaze at any temperature, but it is especially useful in electric-fired lowfire and midrange work, where the exposed claybody often looks pallid and lifeless, and where the glaze often benefits from more surface activation. A terra sig can bring interesting color and surface to unglazed areas, even at midrange and highfire temperatures, and it will give more variegation of color and visual texture in the glazed areas. If you are going to coat the foot and/or lid seats of the pot, be sure to use a terra sig appropriate for the intended firing temperature (see the section

above on "Firing Ranges and Natural Clay Colors Achieved with Terra Sig"). That doesn't preclude using a Redart terra sig on cone 10 wares - it simply requires that you use wax resist or sponge off the foot and/or lid seats.

Is it Possible to Make a Terra Sig that Develops a Gloss with No Polishing?

I believe that my reference to "super refined terra sig" is appropriate in the context of other contemporary studio terra sig processes, but it has come to my attention that the glassy surfaces on classic ancient Greek red-figure and black-figure wares were achieved with little or no polishing, and thus the terra sig must have been refined to a far greater degree. Recently I was contacted by a man conducting experiments to create such a sig. His process starts out like mine, but after concentrating the liquid back to a specific gravity of 1.20, he repeats the whole process again, and again, and again, I believe about ten times. This approach is ripe for experimentation. On the second and subsequent siphonings, you won't encounter any distinct layer of identifiable sediments, and will have to simply sacrifice some arbitrary amount at the bottom of the settled mixture each time - again, an area for experimentation. The beauty of this process is that on the way to re-concentrating the suspension to a specific gravity of 1.20 after each siphoning, you can pause at a specific gravity of 1.15 and try out a bit of sig on a piece of bone-dry clay to check the degree of spontaneous gloss.

Hearing about this approach caused me to consider my own terra sig process, and I came to the realization that I already have definitive proof that this works – that an ultra-refined slip with much finer average platelet size will give a greater spontaneous shine without polishing. I usually concentrate the siphoned suspension with heat, in which case I can completely dry out five gallons of sig in 24 to 48 hours. On occasion, when there is no rush, I'll let a batch dry out on its own in a big stainless steel bowl sitting in a quiet corner of my studio. That takes a lot longer, usually at least a month, and it is a matter of days before the level begins to drop noticeably. A coat of terra sig adheres to the sides of the bowl as the liquid level drops, and the quality of that sig coating changes distinctly from top to bottom. Characteristically, when I come back to harvest the dry terra sig, there is a very narrow band of satin-finish sig around the very top, and immediately below that band the sig is very glossy, with a band of shiny sig at least several inches wide. The surface is not as shiny as the best Greek Attic pots, but it's a very good gloss. A few inches above the bottom of the bowl, the layer starts to get thicker, and also more matt. In the bottom of the bowl is a half-inch-thick layer of cracked "mud flats" of dry terra sig, and the surface of that material is completely matt.

So what's happening to produce that spontaneous high gloss? When the bowl of suspension is initially left to concentrate, water is already evaporating before any appreciable amount of sig particles have settled, since the particles are so fine and are deflocculated. Thus, the very narrow band deposited at the upper edge of the liquid contains an average range of the platelet sizes in the sig. But after a few more days there has been noticeable settling, leaving only ultra-fine particles that have still overcome gravity concentrated at the top. It might take

ten days for the level to drop an inch, and by then the platelets remaining in suspension will be only the very finest that are present. That will be the case as the level drops a few more inches, with only the finest particles in the coating. But as the level drops to the lower levels where there is still a broader mix of particles in the drying sig, the coating thickens and the finish dulls, and when you get to the bottom, you've got a concentration of coarser particles and a matt surface.

It might seem like the obvious solution would be to simply allow a longer settling time. That would give you a smaller yield, but it would develop a greater degree of spontaneous shine, and would probably be easier to polish further. Is there any disadvantages to this? Yes, at least with the way most people use terra sig. Multiple layers of sig generally soften the fine surface texture, especially on sanded wares, and that is at least partially responsible for the expected look of terra sig. Super-sharp micro-details are softened slightly, and that requires a buildup of layers. With a finer distribution of particles in the kind of ultra-refined terra sig described above, the shrinkage would be greater, especially in firing, and there would certainly be a considerable increase in cracking and flaking if the sig coating has been built up in multiple layers. A sig with a much finer distribution of particles would tolerate only very thin application.

It makes perfect sense that an ultra-refined sig such as the Greeks probably used would give two results very advantageous to them. First, it would give very good color coverage and opacity even with an extremely thin layer. With my sig recipe, when the first few coats of sig still seem transparent, it's because we're just seeing the base clay between the particles in the layer of sig, so a finer sig would have far smaller spaces and thus be more opaque. Second, it would give a high gloss with little or no polishing. The Greeks no doubt prepared the surface in advance to give the degree of smoothness desired before applying the sig, and thus a thin layer sufficed for all their needs - opacity, uniformity, color, and shine.

Additionally, there is good evidence that such an ultra-refined sig would have a lower sintering temperature, and thus would vitrify enough to lock in the black color resulting from reduction atmosphere at the end of the firing, while a slightly less-refined terra sig would remain porous at the same maturation temperature and would re-oxidize to red, buff, or white, depending on the clays used in formulation. This is likely the key to the ancient Greek firing process that produced those amazing black-figure, red-figure, and white-ground vessels.

My recipe was devised to satisfy particular needs of bonfired and sagger-fired pottery, as seen in a number of different ancient and tribal traditions, but it is derivative of no single tradition. It is necessarily a compromise. The 20-hour settling time and 1.15 specific gravity for application give the combination of performance features needed. Claybodies intended for bonfiring must necessarily contain a high percentage of tempering material (my bonfiring body contains 25% extra-fine grog) to give the thermal-shock-resistance to survive the abrupt

temperature changes in bonfiring. Sanding the surface leaves a gritty finish, and the particle range in my terra sig is coarse enough to allow build-up of layers to eliminate the sanded texture, and fine enough to allow a high polish with relatively little effort (as compared to burnishing).

If your objective is to make an ultra-refined Greek-style terra sig, it is conceivable that successive repeated settlings and siphonings as described will produce a superior product containing only the very finest particles, as compared to a single longer settling. This is as area for some exciting research.

A well-prepared terra sigillata is truly a remarkable medium. It has become a popular option in contemporary ceramics throughout the US, Canada, Europe, Australia, New Zealand, and parts of the Middle East, where it was invented at least 3000 years ago. Polished terra sig finishes have become especially popular in pit-firing, bonfiring, sagger-firing, sawdust-smoking, raku, and horsehair effects. Whatever you do with terra sig, you are part of a 3000-year tradition that continues to evolve. If you discover interesting new effects or uses in your experiments, I'd appreciate hearing about them at vpitelka@dtccom.net.

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