better porcelain

by Antoinette Badenhorst

There is a constant strive by ceramic artists to improve the workability, color, and stability of porcelain clay bodies while also creating bodies that vitrify at cone 6. Few porcelains have all the exact right characteristics, but here are a few tips to get you a little closer.

History Determines the Future

To develop such a porcelain clay body, that will vitrify at a lower temperature (cone 6 versus cone 10), it is necessary to go back in history to reexamine the origin of porcelain to find out what makes it true porcelain.

It took the Western world 2000 years to figure out how porcelain was made, because the Chinese succeeded in keeping their high-firing methods and materials a secret. Their porcelain was made from kaolin and petuntse, in essence exactly what porcelain is made of today, with the only difference that nature provided the perfect balanced materials to the Chinese. Fired at 2372°F (1300°C), it had the ability to become very hard and durable, white, and translucent.

When Europeans were first exposed to porcelain in the early 12th century, it was simply the magic of the white and translucent objects that fascinated them. It was so different from the red majolica pottery that was available in Europe. At first there was just a curiosity about these objects, but when it became clear that only the very rich and most influential part of the population could afford this “white gold,” greed seeped in and everybody wanted it.

The story of European porcelain started in the early 1700s when a young alchemist, Johann Böttger, held in captivity by the King of Saxony, made the first porcelain-like material from alabaster, a translucent and soft limestone, to which he added flux. The first porcelain was mixed a few years later and although not perfect, the mixture of silica, kaolin, and flux vitrified at a very high temperature and set the foundation of the recipes we use today.

My Approach to Testing Porcelain

In my recent testing of porcelain clay recipes, I wanted to stay as close as possible to the ingredients used in traditional porcelains. My intent

Test Recipes for Translucent Porcelains*

was to lower the temperature at which it fires, without sacrificing the properties of vitrification, translucency, and durability. That demanded a closer look at the traditional materials and their chemical makeup.

Silica is a refractory glass maker and filler, available in different mesh sizes with a melting point roughly 3092°F (1700°C.) Kaolin (also known as china clay) is a refractory aluminum silicate, with an average melting point around 3275°F (1800°C). Coming from different regions, it may include percentages of iron and titanium that will determine its overall whiteness and its potential to become translucent. Fluxes are melters that help to lower the temperature at which of clay bodies and glazes will mature. Depending on their composition, some will function at ^6, filling the voids between the silica and clay particles, and activating chemical change by binding the refractories into a strong glass-like mass. Because there are a broad variety available in the world, each one will have a different effect according to their composition.

After examining the melting temperatures of these raw materials, it became clear that using a lower-firing flux lowers the temperature at which the porcelain will mature. I had to find the purest among them and one that will balance with the other ingredients and melt at least at cone 6. The question was, what will activate the silica and kaolin enough to bring a strong translucent porcelain forth?

I followed the traditional porcelain recipe of 50% fluxes (in this case G200 HP feldspar/minispar), 25% silica (200 mesh), and 25% kaolin. The kaolins I tested were Grolleg China Clay (GCC), Edgar Plastic Kaolin (EPK), New Zealand Halloysite (NZK), and Tile #6 kaolin. I tested them separately, as well as in combinations with each other.

For plasticity, I used C&C ball clay (C&C BC) in some recipes. When I used the ball clay in variations of 5–10 %, I decreased the silica by 15–20% and reduced the kaolin proportionally to keep a total clay content of 100% throughout the recipes. To these recipes I added bentonite for plasticity, just enough to make it workable. **Note:** Ball clay has a high silica content that could possibly overload the clay body.

Test bowl #7 with 10% NZK + 15% Tile #6: produced a more stable, white porcelain with less translucency, but more stability in the fire.

Test bowl #1 with 25% EPK: a stable porcelain with a grayish white color, good translucency and vitreous.

Ingredients	Recipe #1	Recipe #2	Recipe #3	Recipe #4	Recipe #5	Recipe #6	Recipe #7
EPK Kaolin	25						
China Clay		25		15		10	15
Halloysite			60	10			10
Tile #6					25	15	25
Silica	25	25	20	25	25	25	25
Minspar	25	25	20	25	25	25	25
G200HP	25	25		25	25	25	
Total	100	100	100	100	100	100	100
Veegum T							
Macaloid	2	3	10	2		5	2
C&C Ball Clay					10		

***Note:** These are strictly tests. Further testing, with materials available in your area, should be done to create stable porcelain clay bodies

Test bowl #4 with 10% NZK + 15% Grolleg: nice ice white color and good translucency, but needs a stabilizer to prevent slumping.

My objective was to test for whiteness and translucency, therefore I looked for impurities and opacifiers in the analytical make-up of the kaolin as well as the ball clay: Grolleg and EPK are similar in composition with little differences in iron content, but Grolleg has 0.30% less titanium than EPK. Tile #6 is significantly lower in iron, but has 1% more titanium than Grolleg. Of the four kaolins I tested, NZK contained a fraction less clay and more silica than the other kaolins making it the whitest and most translucent. It was less plastic, but with only 0.25% iron and less than 0.1% titanium, I was excited to test for a translucent, and at the same time an ice white porcelain clay body.

Although plasticity was not my focus, I used C&C Ball Clay in some recipes. With more iron, silica, and titania and less clay than the kaolins,

both translucency and whiteness were sacrificed, but it resulted in a more stable porcelain.

Test bowl #2 with 25% Grolleg: slightly whiter and Test bowl #3 with 60% NZK: very translucent, somewhat more translucent than EPK. Slumped needs a stabilizer, shrinks more than other somewhat in the firing. kaolin-bearing porcelains, clear glaze crazed.

Test bowl #5 with 25% Tile #6 + 10% C&C BC: Test bowl #6 with 15% Tile #6 + 10% C&C BC: limited translucency where thin, has a yellow whiter, but less translucent than Grolleg and undertone, good white stable porcelain. more stable in firing.

My test tiles were bowl shapes that I press molded from slabs. This method allowed me to maintain a standard thickness and size and I could easily measure the shrinkage. I did not test for vitrification. All tests were conducted in an electric kiln that was fired to cone 6.

Results

Tile #6 kaolin, with its much higher titanium content, but lower iron content than EPK and GCC kaolins proved to have more plasticity and was more stable than GCC and NZK. Therefore, I came to the conclusion that Tile #6 required more testing. In the figures 1–7, I used 5% more Tile#6 than the more translucent counterpart.

When testing to find a translucent porcelain, it is important to consider the following facts: • Clay for white, translucent porcelain is more expensive, shrinks more, but vitrifies better.

- Porcelain contains less clay and more fluxes; therefore, it will be less plastic to form and will slump easier in the firing.
- More silica in a clay body will improve the glaze fit.
- A coarser silica mesh size will help to improve stability, but will lower the plasticity.
- A finer silica mesh size reacts better to fluxes and improves the bond between silica and kaolin for a harder porcelain.
- During firing silica invert to crystobalite in the clay body. Excessive silica (30% and higher) will not dissolve in the fluxes and result in dunting.
- Kaolin has a particle size 10 × larger than other clay, which causes porcelain to collapse easily on the wheel, when too much water is used. At the same time, because of the open structure of porcelain, it may dry too fast. The wetting and drying process must be carefully controlled. (Why?)
- When plasticizers are added to porcelain clay, it may increase the workability, but a negative effect of too much plasticizers may cause for it to dry too slow, causing difficulty to work with. Therefor a fine balance between the use of plasticizers and the traditional silica, kaolin and fluxes is recommended. (Why?)
- More feldspar will improve vitrification and translucency, but a good balance with silica must be maintained to prevent warping, especially when lower firing feldspars and frits are used.
- Some feldspars like nepheline syenite contain soluble materials that can cause flocculation of the clay that will make it hard

ven when the clay is not dry.

ers improve workability, but can also affect the hrinkage of a porcelain. Be aware that some egum have fluxing effects.

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