

# Glaze Formula: Cost-Effective Flux System

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The fusibility of glaze formula for ceramic sanitaryware and tiles products can be obtained through different fluxes, such as minerals, frits, oxides. For these two applications, Imerys Ceramics developed new feldspars and maximised their yield by modifying the glaze formulas. This successful process resulted in more cost-efficient formulas.

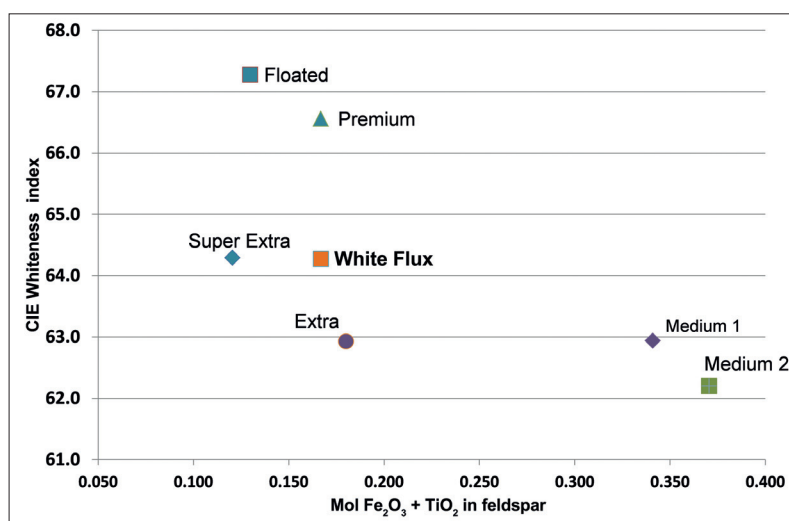


Fig. 1 Feldspar whiteness in a typical sanitaryware glaze formula

## Lithium-based feldspar

Imerys Ceramics' White Flux is a mixed sodium and potassium feldspar containing lithium. The natural presence of lithium in the deposit makes White Flux more fusible than traditional mixed feldspars.

To reach a high level of purity, Imerys Ceramics decided to process its White Flux to eliminate any traces of unsuitable elements. This smart chemical-free process, makes

Tab. 1 Chemical analysis of the lithium-based feldspar

Chemical Analysis	Amount [mass-%]
SiO <sub>2</sub>	73,1±1,5
Al <sub>2</sub> O <sub>3</sub>	16,5±1,5
Fe <sub>2</sub> O <sub>3</sub>	<0,15
TiO <sub>2</sub>	0,04±0,02
K <sub>2</sub> O	3,4±0,3
Na <sub>2</sub> O	4,2±0,5
CaO	0,3±0,1
MgO	0,05
P <sub>2</sub> O <sub>5</sub>	0,3
Li <sub>2</sub> O	>0,8
L.o.I. [%]	1,1

White Flux very clean, suitable for white and high-quality ceramic formulas.

White Flux presents a good balance of alkali (Li<sub>2</sub>O, K<sub>2</sub>O, Na<sub>2</sub>O) allowing an exceptional fusibility profile. In addition, thanks to its low sintering temperature, it offers:

- high efficiency in low firing glazes
- high-quality glazes with good surface aspect – low level of impurities prevents defects in glazes
- more economical formulas – after reformulation, Imerys Ceramics' White Flux can replace expensive fluxes like nepheline syenite with similar performance
- environmentally friendly formulas – unlike most lithium feldspars, White Flux has a low level of fluorine.

The typical content of chromophore oxides of the White Flux is 0,19 mass-% (TiO<sub>2</sub> and Fe<sub>2</sub>O<sub>3</sub>, Tab. 1). The whiteness developed during the firing puts White Flux at the same level as the Super Extra Sodium Feldspar, which has a lower chromophore content (Fig. 1).

The fusibility of the lithium-based feldspar is characterised by an early shrinkage compared to sodium feldspars (Fig. 2). This early sintering point allows the glaze to start softening and reacting with other

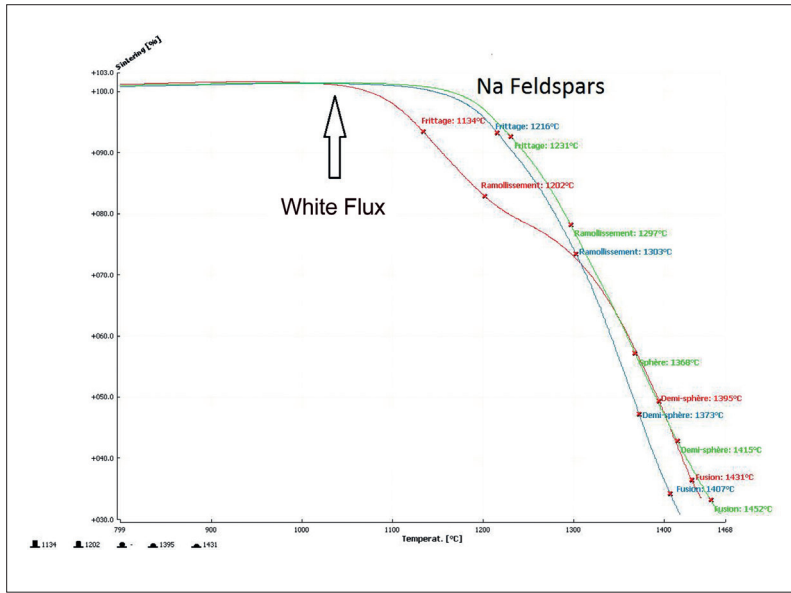
components of the glaze. This reactivity will lead to a quicker glass phase formation with the digestion of other components. The viscosity of this glass phase is the main control parameter in order to obtain the full benefit of the lithium-based feldspar.

Nevertheless, an early melting point also means less time for the gases to escape from the ceramic body. Therefore, the glaze formula has to be adjusted to allow the glass phase formation to start the digestion of different components and at the same time, to allow gases from the body not to be trapped in the glass phase.

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**Fig. 2** Melting curves of feldspars

**Tab. 2** Imerys Ceramics' reformulation of a sanitaryware glaze formula

Raw Material	Standard [mass-%]	New Formula [mass-%]
Feldspar K	27,5	23,0
Silica	27,0	28,0
CaCO <sub>3</sub>	18,4	18,4
Kaolin Imerys	7,5	7,5
Zirconite	11,0	10,0
Frits	6,0	5,0
Zinc oxide	2,0	1,5
White Flux	0	6,0
Bentonite	0,5	0,5
CMC	0,1	0,1
TOTAL	100	100

-6% cost



**Fig. 3** Fusibility and glaze compression tests

### Imerys Ceramics' sanitaryware glaze example

Imerys Ceramics used lithium-based feldspar to reformulate the glaze formula with less frits. The whiteness and opacity generated by the lithium-based feldspar allow reducing the amount of zinc oxide and sometimes the zirconium silicate.

Imerys Ceramics' new formula offers higher fusibility, better whiteness and glossiness as well as opacity (Fig. 3, and Tab. 2). The higher fusibility allows to enhance the surface quality of the glaze, reduces the number of defects and lowers their size, making them invisible to the eye.

### Flux combinations for tiles glaze

The combination of complementary minerals is another way to improve flux efficiency: on one side, by creating eutectics and on the other side, by generating crystalline and/or vitreous phases, resulting in different opacity and whiteness than the standard fluxes. Imerys Ceramics has developed Ceraflux Cotton in order to develop high whiteness during firing with high fusibility. Ceraflux

Cotton is a mix of minerals based on feldspar and calcium bearing minerals. Its chemical analysis shows a higher chromophore content than other high grade feldspars, but it also presents a higher level of whiteness.

The fusibility of Ceraflux Cotton is measured by the height reduction of a cone during firing (Fig. 4, and Tab. 3).

Imerys Ceramics' Ceraflux Cotton has a mineral combination which makes it a balanced product and enables it to obtain a high level of whiteness and fusibility with good opacity.

Tab. 4 shows the ceramic performances of Ceraflux Cotton compared with those of other types of Ceraflux materials.

**Tab. 3** Typical chemical analysis, fired color and fusibility of fluxes mined in Thailand

Product	Type	Application	Chemical Analysis [mass-%]									Fired at 1250 °C			
			SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	TiO <sub>2</sub>	CaO	MgO	K <sub>2</sub> O	Na <sub>2</sub> O	L.o.I. [%]	L*	a*	b*	Fusion
M200S	Mix feldspar	Glaze	68,1	17,6	0,20	0,12	0,67	0,01	5,33	7,16	0,49	77,6	0,05	11,0	50,0
M200Q	Mix feldspar	Glaze	68,0	17,5	0,25	0,10	0,44	0,16	6,05	6,70	0,80	78,9	-0,28	11,7	47,1
<b>Cotton</b>	<b>Mix feldspar</b>	<b>Glaze / Engobe</b>	<b>68,1</b>	<b>15,7</b>	<b>0,34</b>	<b>0,11</b>	<b>1,39</b>	<b>0,44</b>	<b>5,62</b>	<b>7,38</b>	<b>0,61</b>	<b>79,0</b>	<b>-0,44</b>	<b>4,45</b>	<b>64,4</b>
FG	Mix floated feldspar	Glaze	67,6	18,4	0,17	0,01	0,96	0,01	6,05	6,52	0,20	78,3	0,11	4,06	48,8
SP SPAR AGP	Mix feldspar	Glaze	67,0	18,3	0,15	0,01	0,46	0,01	6,03	7,46	0,43	79,7	-0,02	5,83	49,1

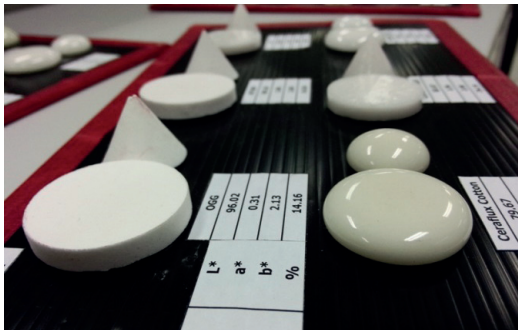


Fig. 4 Fusion cones of sodium feldspar vs. Ceraflux Cotton

Tab. 4 Imerys Ceramics' feldspars performances

Product	Fusion	Whitness	Opacity	Application
Ceraflux N200L	3	1	4	Glaze / engobe
Ceraflux KF200	1	3,5	1	Glaze
Ceraflux M200Q	2	2	3	Glaze / engobe
Ceraflux Q200	4	3	2	Glaze / engobe / low fired / nepheline replace
<b>Ceraflux Cotton</b>	<b>3,5</b>	<b>4</b>	<b>3</b>	<b>Glaze / engobe / low fired</b>

### Imerys Ceramics' reformulation example

The main characteristic of Ceraflux Cotton is its high fusibility, therefore the frit content of the tile engobe has been reduced by 8 % and the sodium feldspar content by 4 %.

Imerys Ceramics adjusted the content of the other components in order to balance the formula (Tab. 5). The new formula is more cost-effective and presents the same fired properties in term of opacity, whitness and water mark characteristics (Fig. 5). High whitness and fusibility fluxes using lithium-based feldspars or different minerals combinations are cost-effective solutions in sanitaryware glazes and tiles engobe.

The chemical composition of the fluxes does not always reflect the fired performances of the system. The generation of new crystalline phases during the firing allows extra fusibility and uses cut-rate components.

Tab. 5 Example of the standard and new formula using Ceraflux Cotton

Raw Material	Standard	Trial No. 9
<b>Frit</b>	<b>41</b>	<b>33</b>
Feldspar	14	10
Ball clay	13	13,5
Kaolin	5	4
Silica	5	7
Alumina	10	8
Talc	2	—
Cullet	10	10
Bentonite	2,5	1
<b>Ceraflux Cotton</b>	<b>—</b>	<b>16</b>
CMC	0,05	0,05
STPP	0,15	0,15

-17% cost



Fig. 5 Firing test of the standard (l.), and the new engobe formula (r.) for ceramic tiles

In order to obtain the full benefit of the Imerys Ceramics solutions presented above, a deep reformulation work adapted to the

industrial process regarding manufacturing of both ceramic sanitaryware and tiles has to be done.