SELECTION OF RAW MATERIALS TO DEVELOP BLENDS OF MINERALS DESTINED TO REDUCE THE PYROPLASTIC DEFORMATION OF PORCELAIN TILES

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1. INTRODUCTION

The production of porcelain tiles has seen growing rates in Brazil and around the world in the last decades related to good acceptance of this product on the global market[1]. In Brazil, between 2000 and 2015, porcelain tiles had annual rates of growth of over 10%. Besides increasing sales of this product in the market, in recent years the demand for porcelain tiles of large sizes (larger than 60 x 60 cm^2) increased considerably. However, the production of porcelain tiles in large sizes has generated some technical challenges. Deformation presented by pieces with large dimensions during sintering—pyroplastic deformations—became determinant to the dimensional accuracy of porcelain tiles produced. Pyroplastic deformations[2] are defined as permanent deformations that occur at high temperatures, deriving from the mechanism of sintering in the presence of liquid phases, predominant in the firing of vitrified ceramic materials, as porcelain tiles. The deformations are related to the volume and viscosity of the liquid phases produced during the sintering, among other factors. Considering the demand for large size porcelain tiles of high dimensional accuracy, the purpose of this study was to develop blends of minerals that could be added to the composition of porcelain tiles, aiming to reduce the pyroplastic deformation suffered during sintering. In the first stage of this work, raw materials were tested individually and, subsequently, they would be combined to others to produce the blends referred to.

2. MATERIALS AND METHODS

The potential of five raw materials (albite, granite, feldspathoid, filite and residue from the production of rectified porcelain tiles) was evaluated to reduce the pyroplastic deformation of a standard composition destined for production of glazed porcelain tiles. The raw materials tested were previously milled in ball mills under two different conditions: until achieving residue of 45 μm between 2% - 5%; and micronized until achieving D_{50} near 2 μm. Particle size distributions of the powders obtained were determined by sedimentation technique in Sedigraph 5000d.

All the milled raw materials were added in the proportion of 5%wt in an industrial slurry used for the production of porcelain tiles. The compositions were then dried at 110 °C and granulated in laboratory sieves in the presence of 7.0% water. Prismatic bodies of 60x20x5 mm^3 were pressed in an automatic press to obtain apparent bulk density after drying all the bodies equal to 1.89 ± 0.01 g/cm^3 (the range of applied pressures in the bodies was about 380 – 415 Kgf/cm^2). The bodies obtained were fired at different temperatures in a laboratory roller kiln, using 40-minute cycles. The water absorption and lineal firing shrinkage of the fired specimens were determined to generate the vitrification curves. The pyroplastic index of the bodies fired at temperatures required to achieve 0.5% water absorption were finally analysed in 100x10x5 mm^3 specimens.

3. RESULTS AND DISCUSSION

Fig.1 shows the vitrification curves of bodies containing 5% of each tested raw material in two different particle sizes distributions. The results indicate that the raw materials are effective for reducing the firing temperature of the bodies, especially when they are micronized. The feldspatic raw materials (albite and granite) and the porcelain tile residue produced greater reductions in firing temperature of the bodies. Pyroplastic indices are presented in Table I. It is possible to verify that the tested raw materials can be used to reduce the pyroplasticity of the STD body. The small particle sizes of these raw materials anticipate formation of liquid phases during firing and permit solubilization of quartz[2]. Consequently, the viscosity of the liquid phases increases and the pyroplasticity of the body can be reduced.

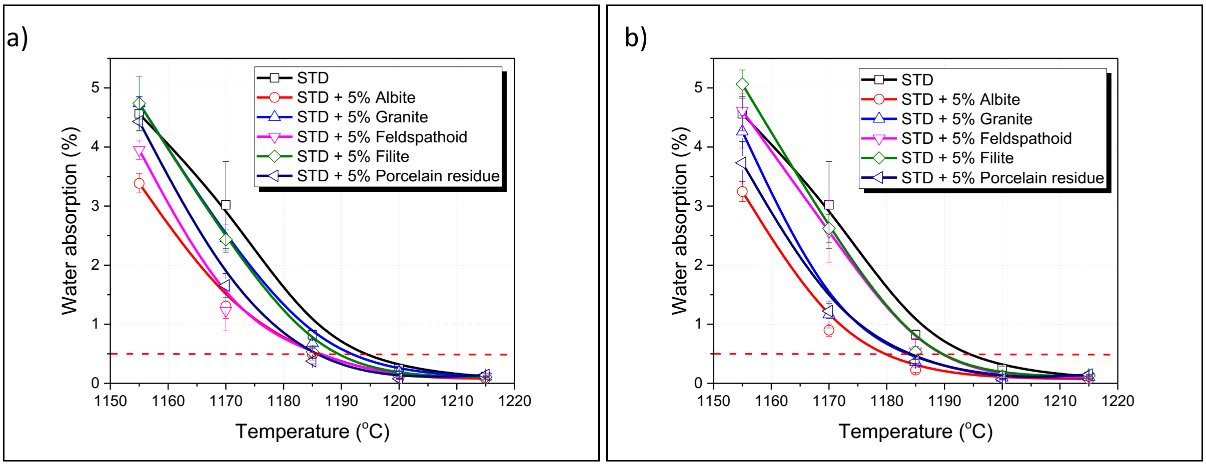

Figure 1. *Vitrification curves of the bodies. a) Raw materials added to the STD body with residue 45 μm = 2% - 5%; b) Raw materials added to the STD body with* D_{50} *= 2 μm.*

Compositions	Particle size	Firing Temperature (°C)	Pyroplastic Index (cm^{-1})
STD	STD	1195	6.1×10^{-5}
STD + 5% Albite	Fine	1187	5.4×10^{-5}
	Micronized	1180	5.5×10^{-5}
STD + 5% Granite	Fine	1192	5.9×10^{-5}
	Micronized	1184	5.4×10^{-5}
STD + 5% Feldspathoid	Fine	1190	5.1×10^{-5}
	Micronized	1187	4.4×10^{-5}
STD + 5% Filite	Fine	1190	4.8×10^{-5}
	Micronized	1190	3.8×10^{-5}
STD + 5% Porc. Residue	Fine	1186	5.0×10^{-5}
	Micronized	1184	4.2×10^{-5}

Table II. *Firing temperatures and pyroplastic index of the bodies*

4. CONCLUSIONS

Fluxing raw materials with small particle sizes are effective to reduce the firing temperature and the pyroplastic index of glazed porcelain tiles. They anticipate the formation of liquid phases during firing and increase the solubilisation of quartz in the vitreous phase. Fluxing agents that contain quartz and lower sodium content are less effective reducing the firing temperature. However, they are more useful in reducing the pyroplastic index than feldspars with high alkali content in their compositions. Generally, the effects referred to are more pronounced with micronized raw materials.

5. REFERENCES

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[2] CONSERVA, L.R.S. et al. Pyroplastic deformation of porcelain stoneware tiles: Wet vs. dry processing. Journal of the European Ceramic Society, 37, (1), p.333-342, 2017.