PHASE FORMATION OF VISCOUS FLOW SINTERED CERAMICS

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1. INTRODUCTION

This work describes investigations carried out on ceramics sintered by viscous flow with emphasis on phase formation. Porcelain stoneware tile can be seen as a typical commercial product sintered by the viscous flow mechanism. Amongst the various types of ceramic tile materials that are produced, porcelain stoneware tile stands out due to its technical properties (low water absorption, high mechanical strength and abrasion resistance, high resistance to chemical attack and high frost resistance) and its similarity to natural stones.

The world production of the porcelain tile has increased continuously in the last two years. Presently, the amount of production in Italy has already surpassed 50% of all the production of ceramic tiles in that country. Spain and Brazil have also invested in this typology by increasing their installed productive capacity and through the development of productive technology.

A basic composition for the porcelain tile consists of 42 to 48% of feldspar. Studies have suggested a possible insufficiency of the Brazilian mining sector to provide for the need of fluxes, considering the maturation period of the necessary investments, with a predicted increase in the imported amount of this raw material. For this reason, there are many studies aiming at the replacement of feldspar by one or more fluxing natural raw materials. However, the replacement of feldspar by a previously obtained vitreous phase can lead to viscous flow, like the one commonly obtained during firing of glasses and glazes.

2. EXPERIMENTAL PROCEDURE

In this work, four compositions prepared by mixing ball clay, kaolin, feldspar, quartz, flux (vitreous phase former, previously prepared from SiO_2, Na_2O and CaO) and talc, were studied:

T: standard composition, based on formulations found in the specific literature;

A: composition based on chemical analyses of a commercial product;

C: composition from partial replacement of feldspar by a flux;

F: composition resulting from total replacement of feldspar by a flux.

The raw materials were wet-mixed (60 wt% solids) in a ball mill in the weight ratio 4:1 (balls: material).

The slurry was spray-dried, resulting in granulated powder with 8% humidity. Powders were uniaxially pressed using a hard steel die at 300 MPa in a hydraulic press. After drying, samples (7x2x1cm) were fired over the temperature range 900-1250°C and similar firing curve (heating rate, time) for all compositions.

The determination of the characteristics of the samples was carried out through the use of physical analysis: water absorption, apparent porosity, firing shrinkage and flexural strength.

3. RESULTS AND DISCUSSION

The results presented in Figures 1 and 2 show better vitrification of the material with replacement of feldspar by the fluxing raw material at lower firing temperatures. This better vitrification observed in compositions C and F may have occurred due to the formation of more viscous liquid phase by the presence of the flux, which caused a more effective reduction in the porosity of the material (Figure 3a).

Regarding the modulus of rupture (Figure 3b), composition F showed higher values than the other compositions, within the range of temperatures up to 1125°C. At temperatures around 1200°C, pyroplastic deformation may be observed in the samples of the former composition, which can be explained by the considerable presence of liquid phase at these temperatures. For the composition with partial replacement of feldspar by the fluxing raw material, similar behaviour was noticed, however, with slightly lower mechanical strength. The composition with only feldspar (T) showed higher values for the modulus of rupture, exhibiting higher porosity (which could be due to higher values of apparent porosity and water absorption). This fact could be regarded as a consequence of the high content of vitreous phase in the samples where the fluxing raw material was employed, which is more fragile than the crystalline phase.

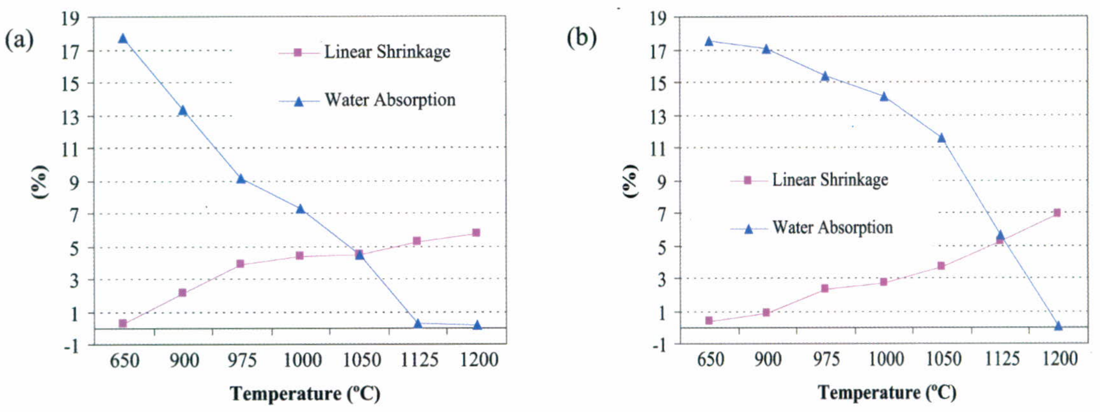

Figure 1. Vitrification diagram: (a) composition F and (b) composition C.

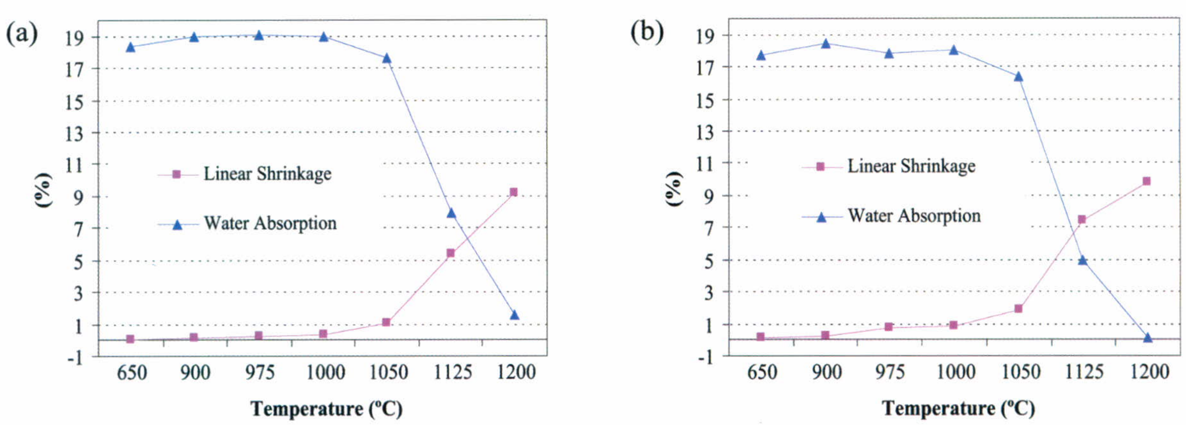

Figure 2. Vitrification diagram: (a) composition A and (b) composition T.

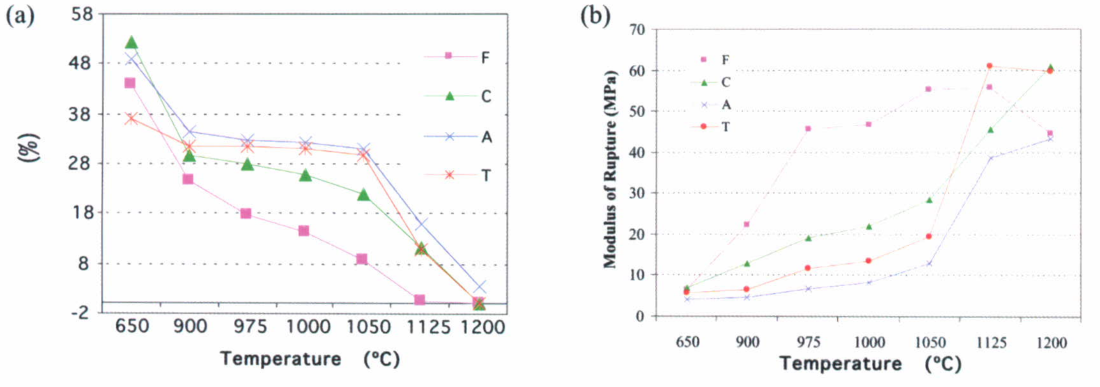

Figure 3. Variation of: (a) apparent porosity and (b) modulus of resistance to flexure as a function of firing temperature for the four studied compositions.

4. CONCLUSIONS

According to the results that have been obtained so far, the addition of the vitreous phase resulted in samples with good physical properties, using lower firing temperatures, which can lead to less energy consumption. In addition, it was possible to substitute raw material of a higher cost - feldspar - by an inert vitreous phase that was previously obtained, without compromising the processing, physical and visual properties of the final product.

5. ACKNOWLEDGMENT

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