FEASIBILITY OF THE USE OF A BRUCITECALCITE BASED RAW MATERIAL FROM TURKEY IN PORCELAIN TILE MANUFACTURING

[1] E. Sánchez, [1] J. García-Ten, E. Bou, [1] C. Moreda, [2] T. Kavas, [2] N. Birinci, [3] M.Y. Çelik

[1] Instituto de Tecnología Cerámica-Asociación de Investigación de las Industrias Cerámicas. Universitat Jaume I. Castellón, Spain.

Universitat Jaume I. Castellón. España.

[2] Afyon Kocatepe University. Afyonkarahisar, Turkey.

[3] Afyon Kocatepe University, AMYO. Afyonkarahisar, Turkey.

1. INTRODUCTION

Recent studies, which have sought to reduce manufacturing costs, have attempted to shorten the porcelain tile firing cycle by introducing highly fluxing additives [1] or wastes [2]. In this context, a calcite-brucite rock, found in large deposits near the city of Afyonkarahisar in Turkey, has been characterised and evaluated for its potential application as a fluxing agent in porcelain tile compositions.

2. EXPERIMENTAL

A sample of calcite-brucite (hereinafter called CB) rock was used in this study. This CB sample was characterised by chemical and mineralogical analysis (XRD), TG-DTA, and microstructural (SEM) observation. A standard (STD) porcelain composition consisting mainly of kaolinitic clay (45 wt%), sodium feldspar (45 wt%), and quartz (10 wt%) was also used. Previously ground brucite-calcite mineral was added to the STD composition in alternate additions of 2 wt% CB, 4 wt% CB, and 6 wt% CB, which yielded three compositions, referenced BR-2, BR-4, and BR-6 respectively. The mixtures were processed by wet mixing, forming by pressing, and fast firing, under conditions that reproduced industrial practice.

The rheological behaviour of the compositions was first evaluated. This was done by obtaining the deflocculation curves of the three test compositions at 69 wt% solids content. The starting powders (moisture content of 5.5 wt% on a dry basis) were uniaxially pressed to produce test pieces with a constant bulk density (ca 1.95 g/cm^3). Fired specimens were then obtained by fast firing cycles (50 min.) with maximum temperatures ranging from 1140 to 1220 ºC. The fired bodies were characterised in terms of bulk density, linear shrinkage, water absorption, and pyroplastic deformation.

3. RESULTS AND DISCUSSION

3.1. Characterisation of the Calcite-Brucite sample.

Chemical and mineralogical analysis showed that this raw material mainly consisted of calcite ($CaCO_3$) and brucite ($Mg(OH)_2$) minerals with negligible amounts of iron oxide and other impurities. TG-DTA analysis confirmed the presence of these two minerals, evidenced by the brucite dehydroxylation peak at 417 ºC and calcite decomposition peak at 857 ºC. Figure 1 depicts a SEM micrograph of the sample. It clearly shows the sheet-like morphology of brucite crystals surrounded by a matrix of granular calcite particles. These characteristics enable this material to be used as a fluxing agent in porcelain tile compositions.

3.2. Characterisation of compositions before firing.

Table 1 presents the rheological parameters obtained from the deflocculating curves. It shows that the 2 wt% CB addition hardly modifies the rheological behaviour of the STD composition. In contrast, a larger amount (4 wt%) is observed to have a significant negative effect on viscosity and thixotropy. For this reason, the BR-6 composition was not tested. No differences were observed in pressing behaviour between the STD compositions and the compositions containing the CB sample.

Compositions	STD	BR-2	BR-4
Solids content (wt %)	69.3	69.3	69.4
Deflocculant content (wt %)	0.28	0.27	0.36
Viscosity (cP)	760	800	1880
Thixotropy (cP)	1480	2200	2850

Table 1. Deflocculating behavior of the studied compositions.

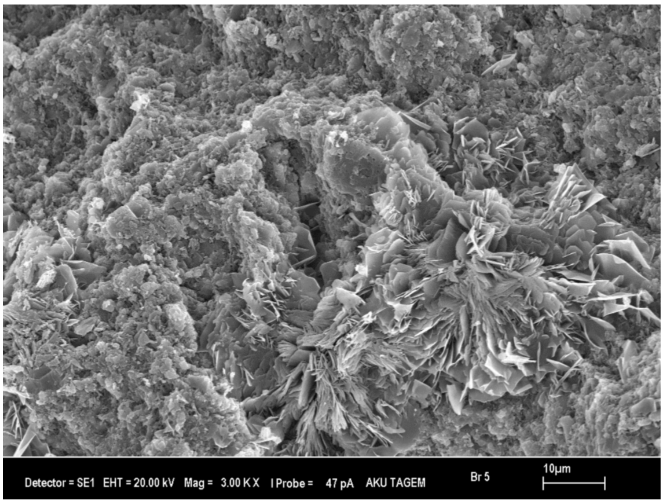

Figure 1. SEM micrograph of CB sample.

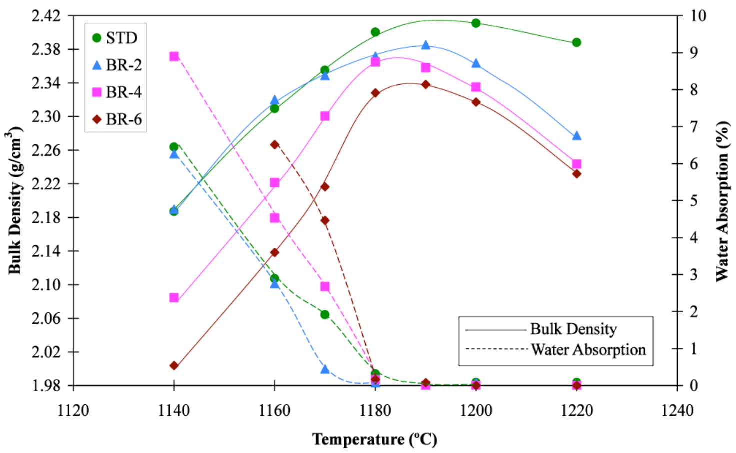

Figure 2. Firing behaviour diagram (bulk density and water absorption) versus firing temperature for the test compositions.

3.3. Firing behaviour and characterisation of fired specimens.

The evolution of bulk density and water absorption versus temperature of the test compositions is plotted in Figure 2. The figure shows that a 2 wt% CB addition reduces the firing temperature at which maximum densification occurs and narrows the firing range. This fluxing effect can be quantified at almost 10 ºC per 1 wt% CB addition. However, a larger CB addition does not follow the same trend. In contrast, an unexpected reduction in bulk density was observed. Furthermore, XRD patterns were obtained of the fired specimens at maximum firing density. A new crystalline phase, a calcium plagioclase rich in sodium was detected which could explain the reduction of the fluxing effect on increasing the amount of CB.

With regard to mechanical strength, no variation in this property was found for the BR-2 composition compared with that of the STD composition. But again, further additions led to decreased mechanical strength, in particular for the BR-6 composition. Finally, the pyroplasticity index exhibited a similar evolution to that of mechanical strength: a 2 w% addition did not alter the pyroplastic behaviour of the STD sample (some improvement was even detected), while higher CB additions impaired this property. Further research is now in progress to explain this firing behaviour.

4. CONCLUSIONS

The study shows that a 2 wt% addition of this raw material (calcite-brucite) to a standard (STD) porcelain tile composition reduces the firing temperature of the STD composition without significantly altering the processing variables. However, further additions of this mineral do not lead to a fluxing effect, while they impair the processability of the STD composition.

REFERENCES

[1] Composición innovadora de gres porcelánico (ECOKER ®) [on-line] Castellón: Instituto de Tecnología Cerámica - AICE, 2008. http://www.observatoriotecno logicoceramico.es/itc/export/sites/default/itc/down-gallery/ Composición_innovadora_de_GP.pdf [Accessed: 2008-10-20]

[2] Tucci, A.; Rambladi, E.; Esposito, L.; Use of scrap glass as raw material for por elain stoneware tiles. Advances in Applied Ceramics, 105(1), 40-45, 2006.