EFFECT OF CALCITE ADDITION ON SINTERING BEHAVIOUR OF A MODEL CERAMIC WALL TILE BODY

A. Kucuker[1,2], K. Kayacı[1], & A. Kara[2]

[1]Termal Seramik Sanayi Ltd., Bilecik, TURKEY
[2]Anadolu University, Dept. of Material Science and Eng., Eskisehir, TURKEY

ABSTRACT

In this study, effect of various amounts of calcite addition on sintering behaviour of a model ceramic wall tile body, mainly consisting of a local sandy clay, was investigated and the results were compared with those obtained from a commercial formulation. The sintering behaviour of the bodies was evaluated using a double-beam optical non-contact dilatometer. XRD was also used to analyse the phases formed after firing. Microstructural and microchemical characteristics of the fired body were observed using scanning electron microscopy (SEM). Finally, the physical and mechanical properties of the investigated bodies such as water absorption, linear firing shrinkage, bulk density, whiteness and breaking strength were measured.

1. INTRODUCTION

Carbonates are important constituents of ceramic wall tile bodies produced by single or double firing process. The presence of carbonates in the formulations and the reactions that occur between them and other components modify body properties. Open porosity and consequently water absorption result from decomposition of the carbonates. The reactions of the resulting oxides with other materials form new phases (such as gehlenite, anorthite and wollastonite) that affect important properties such as dimensional stability with temperature and moisture expansion[1, 2].

The main aim of this work was to study the sintering behaviour of a model ceramic wall tile body, mainly consisting of a local sandy clay, with increasing amount of calcite incorporation. Accordingly, it was also aimed to develop a new formulation with the fast firing behaviour and the technological properties similar to those shown by the commercial formulation but employing reduced number of raw materials for ease of operation and cost saving purposes.

2. MATERIALS AND METHODS

Several formulations were prepared with sandy clay (designated as SC) and marble containing sandy clay (designated as SC1 and SC2).

RAW MATERIALS	WALL TILE STD	SC	SC1	SC2
Clay (A) + Clay (B)	18.0	-	-	-
Sandy clay (SC)	44.0	100	95	90
Pegmatite	30.0	-	-	-
Marble	8.0	-	5	10

Table 1. Investigated formulations (in wt. %)

The densification behaviour was described in terms of water absorption and linear firing shrinkage in accordance with the standard procedures. Breaking strength values of the representative samples fired under industrial conditions were also measured using the three-point flexural method (Gabrielli S.R.L, Italy). The vitrification behaviour of rectangular compacts of the representative tile bodies was studied using a double-beam optical non-contact dilatometer (MISURA, Expert System Solutions, Italy). The measurements were conducted according to the corresponding industrial firing profile.

Qualitative determination of major crystalline phases present in the fired tiles was achieved by XRD (Rigaku, Rint 2000, Japan) on the powdered samples over a range of 2θ values of 5º to 40º. Microstructural observations were performed on fractured and etched surfaces of some selected fired samples using a SEM (Zeiss Supratam 50 VP) in secondary electron imaging modes after sputtering with a thin layer of gold-palladium alloy in order to prevent charging.

3. RESULTS AND DISCUSSION

3.1. PHYSICAL AND THERMAL PROPERTIES

Table 2 presents some of the important technological properties of the investigated bodies fired at a peak firing temperature of 1150ºC in SITI roller furnace under industrial conditions. Firing shrinkage, water absorption and breaking strength of bodies are close except for the SC formulation. Colour properties of formulations were, however, measured to be almost the same.

FIRING PROPERTIES	STD	SC	SC 1	SC 2
Linear firing shrinkage (%)	0	0.2	+0.05	+0.1
Water absorption (%)	15.6	18.3	14.8	16.1
Breaking strength (N/mm^2)	13.1	6.5	13.2	12.2
Chromatic coordinates				
L*	71.2	69.9	70.4	70.7
a*	7.1	6.9	6.5	4.2
b*	15.8	14.2	15.2	12.7
* positive (+) sign means expansion				

Table 2. Some important firing properties of the investigated bodies fired under industrial conditions (1150ºC for 32 minutes).

Fig. 1 gives the dilatometric curves of the investigated tile bodies obtained using a double-beam optical non-contact dilatometer. As can be seen from the figure, all the sintering curves exhibit expansion from the initial temperature up to 900 ºC. Between 900ºC and 1000ºC clay structure breaks down and the bodies start showing shrinkage behaviour. All the bodies except SC display expansion between approximately 1000ºC and 1150ºC due to the formation of crystalline phases that stabilise the mixtures. Similar behaviours were also reported in the literature for clay materials with calcium oxide content[3-5].

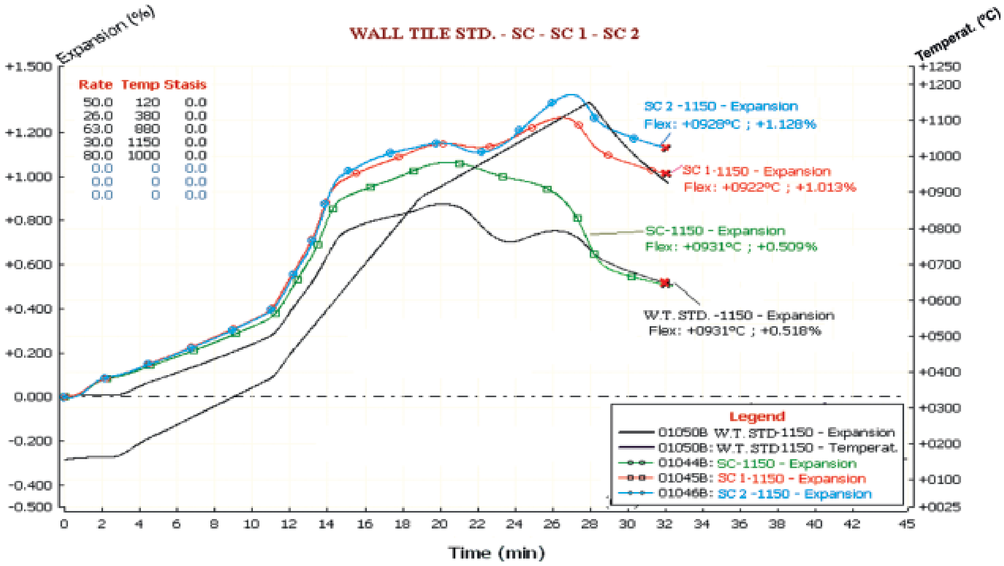

Figure 1. Dilatometric curves of the standard wall tile and investigated formulations (cycle: 1150ºC, 32 min.).

3.2. PHASE EVOLUTION AND MICROSTRUCTURAL ANALYSIS

The crystalline phases present in the investigated bodies after firing under industrial conditions are mainly residual quartz, and plagioclase (albite, anorthite), as shown in Fig. 2. Disappearance of clay and calcite reflections, and change in the intensity of plagioclase reflection indicate the crystallisation of a new phase with an intermediate composition between anorthite and albite.

Fig. 3 illustrates the typical SE images taken on the fractured and etched surfaces of the investigated bodies. The microstructures contain porosity, mainly resulting from carbonate decomposition. In SC formulation, there appears to be no considerable vitrification, which in turn is probably responsible for its low strength (see Table 2). The numbers of pores increase with higher amount of marble due to the calcite decomposition.

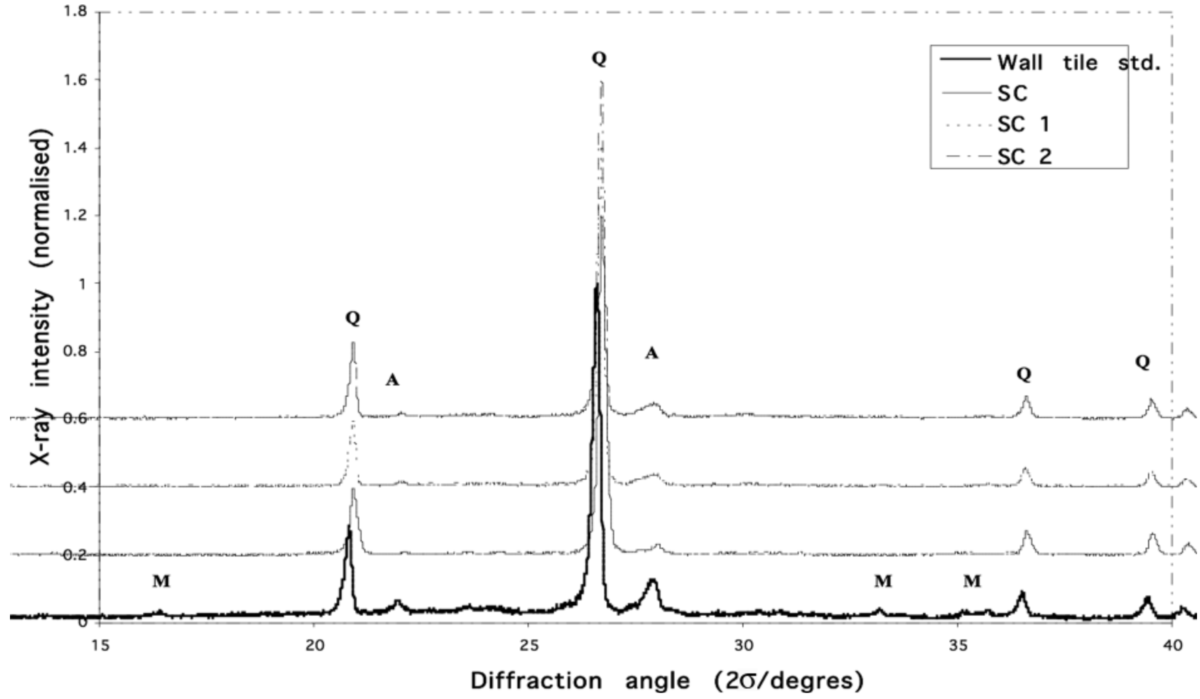

Figure 2. XRD spectra of the investigated fired bodies (cycle: 1150ºC, 32 min.) A: plagioclase (albite, anorthite), M: mullite, Q: quartz.

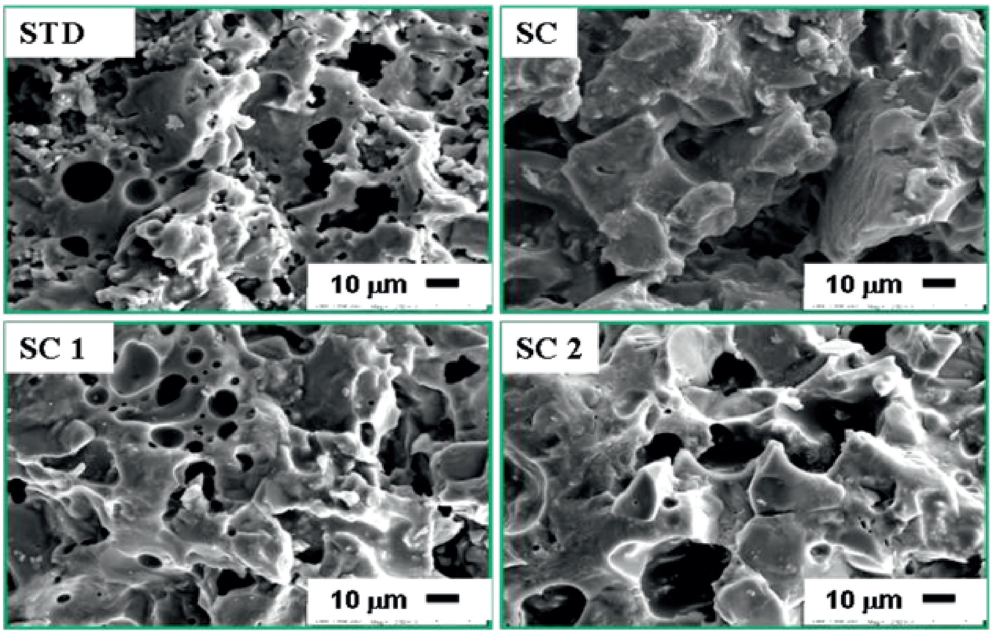

Figure 3. Representative SE images of the fractured and etched surfaces of the investigated formulations (cycle: 1150ºC, 32 min.).

4. CONCLUSIONS

A new wall tile body was developed by simply using a mixture of only sandy clay and marble, both supplied from local sources. This new formulation shows similar firing behaviour and consequently technological properties obtained from the commercial counterpart. The best formulation was found to be the one designated as SC1. New formulation is expected to provide ease of operation and cost reduction for the company. However, further modifications are required to confirm its suitability for industrial application.

REFERENCES

[1] Yekta, B.E. and Alizadeh, P., "Effect of Carbonates on Wall Tile Bodies". *Am. Ceram. Soc. Bull*., 1996, 75(5), 84-86.

[2] Traore K., Ouedraogo G. V., Blanchart P., Jenot J. P., Gomina M., "Influence of Calcite on the Microstructure and Mechanical Properties of Pottery Ceramics Obtained from a Kaolinite-Rich clay from Burkina Faso", *J. Am. Ceram. Soc*., 2007, (27), 1677-1681.

[3] Montorsi M., Reginelli M., Rovini A., Settembre D., Siligardi C., Lugli C.," Reactivities of Carbonates with Illite and Kaolinite in Monoporosa Bodies", *Ceramic World Review* ,n. 69, 2006, 110-120.

[4] Acchar W., Vieira F. A., Hotza D., "Effect of Marble and Granite Sludge in Clay Materials", Materials Science and Engineering, A 419, 2006, 306-309.

[5] Kara A., Özer F., Kayacı K., Özer P., "Development of a Multipurpose Tile Body; Phase and Microstructurel Development", *J. Euro. Ceram. Soc*., 2006, 26: 3769-3782.