MANUFACTURE OF PORCELAIN TILE WITH SELECTED RAW MATERIALS FROM THE NORTHEAST OF BRAZIL

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ABSTRACT

This study examines the obtainment of pressed ceramics of the stoneware type using raw material from the State of Rio Grande do Norte, through the mixture of kaolin, sodium feldspar and quartz. The mixtures were prepared with 10,0%, 12,50%, 15,0%, 17,5% and 20,0% quartz. Test bodies were prepared by uniaxial pressing with firing at temperatures between 1160 and 1240ºC. Tests were conducted on the fired samples for the determination of linear shrinkage, mechanical strength (3-point bending) and water absorption. Microstructure analysis was carried out by scanning electron microscopy. The results indicate that the incorporation of quartz into the mixture produces a reduction of mechanical strength.

1. INTRODUCTION

The State of Rio Grande do Norte displays factors that assure development of the white ceramic sector since, in addition to the reserves of quality raw materials in sufficient quantity for economic exploitation, it has a low energy cost[1].

For ceramic tiles, one of the most important technical characteristics is physical wear resistance; further of note are the low water absorption values and high mechanical strength. The companies of the ceramic tile sector have sought certification of the quality of their products according to the standard ISO 13006[2]. The term tile includes a variety of types, which differ in terms of their properties; water absorption and the modulus of rupture being of fundamental importance. This fact has led to the conquest of international markets, because it satisfies the needs of clients for quality products.

The study examines the obtainment of the white-body ceramic tiles, using the raw materials of the state of Rio Grande do Norte, which conform to standard NBR 13818 (Table 1).

ISO 13006	WATER ABSORPTION (%)	MODULUS OF RUPTURE (MPa)	PRODUCT	RECOMMENDED USE
1a	0 – 0,5	35 – 50	Porcelain tile	Floor and wall
1b	0,5 – 3	30 – 45	Stoneware tile	Floor and wall
2a	3 – 6	22 – 35	Semi-porous tile	Floor and wall
2b	6 – 10	15 – 22	Porous tile	Floor and wall

Table 1. Classification of the groups of ceramic tiles.

2. MATERIALS AND METHODS

2.1. MATERIALS

The raw materials used in the study were provided by the company ARMIL, located in the municipality of Parelhas, State of Rio Grande do Norte, which processed the kaolin, quartz and sodium feldspar. Table 2 presents the chemical compositions and physical tests that were used and Table 3 gives the formulations that were prepared. The oxides and their quantities in each material were also evaluated in the study.

PRODUCT	CHEMICAL COMPOSITION (%)								
	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Na_2O	*LOI
Kaolin	49,07	33,74	0,22	<0,1	0,30	0,061	1,97	0,52	14,01
Sodium feldspar	69,55	18,82	0,14	0,017	0,17	0,09	1,47	9,63	0,32
Quartz	98,97	0,41	<0,01	0,019	<0,01	<0,01	0,18	0,13	0,26
*LOI: loss on ignition.									

Table 2. Chemical composition and tests

RAW MATERIAL	FORMULATION (%)				
	M1	M2	M3	M4	M5
Kaolin	50	50	50	50	50
Sodium feldspar	40	37,5	35	32,5	30
Quartz	10	12,5	15	17,5	20

Table 3. Formulations of the prepared masses.

2.2. METHODS

With the results of the chemical analyses the oxides were noted that most influenced the formulation. All the mass compositions were homogenised by wet milling in a ball mill, keeping the quantity of water used constant during the period for all compositions. The deflocculant used was sodium silicate. The residue of each composition on mesh sieve 325 was between 0,8 and 1%. After milling the slurry was dried in an oven, adding water in a proportion of 7%.

The compaction stage of the test bodies was conducted in a hydraulic press, with a compaction pressure of about 35 MPa, and drying in an oven at 110ºC for 24 hours. All the samples were sintered in oxidising atmosphere at temperatures of 1160, 1180, 1200, 1220 and 1240ºC for 55 minutes. The resulting ceramic bodies were evaluated in terms of the following properties: linear firing shrinkage, water absorption and modulus of rupture. Special attention was paid to the correlation between the formulation of the mass and the firing temperature in relation to the properties of the ceramic bodies. This was in addition to the obtainment of the vitrification diagrams.

3. RESULTS

The X-ray diffractograms of the studied individual samples are displayed in Figure 1 (a), (b) and (c). They show the characteristic diffraction peaks of the crystalline phases relating to kaolin ($Al_2O_3.2SiO_2.2H_2O$), silica (SiO_2), and sodium feldspar ($Na_2O.Al_2O_3.4SiO_2$).

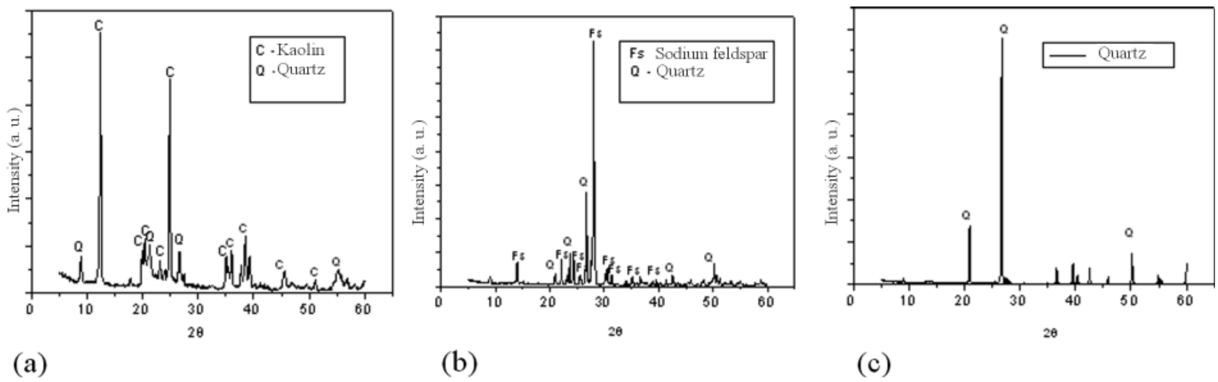

Figure 1. X-ray diffractograms of the raw materials: (a) kaolin, (b) sodium feldspar (c) quartz.

Figure 2 (a) displays the differential thermal behaviour (DTA) of the kaolinites. It shows a small endothermic peak between 50 and 100ºC that is associated with the relative moisture of the material (uncoordinated water loss), typical of kaolinitic materials. Another endothermic peak of greater intensity is observed between 540 and 600ºC, this being related to the formation of metakaolinite ($Al_2O_3.2SiO_2$). Figure 2 (b) presents the reactions that took place during the differential thermal analysis of sodium feldspar. In this figure, a small endothermic peak is detected near 570ºC. This peak develops due the transformation of α-quartz into β-quartz. A second endothermic peak is observed near 800ºC, which is due to decomposition of the carbonates. And finally, a third event is detected near 970ºC, which is related to the appearance of a liquid phase that produces the dimensional variation[3].

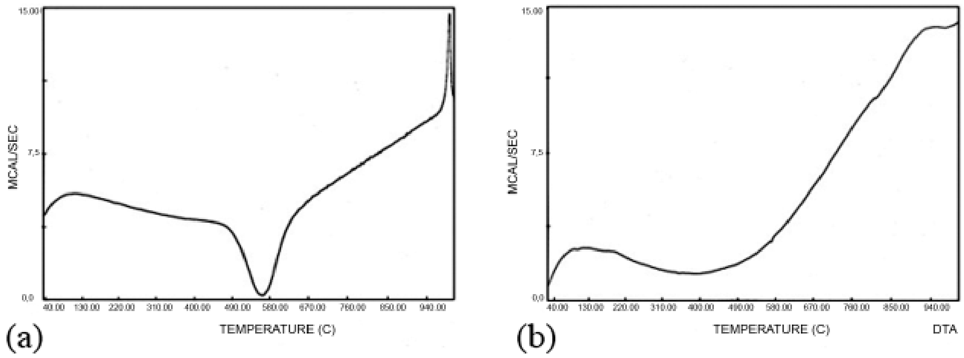

Figure 2. Differential thermal curves (DTA) of the powder: (a) kaolin, (b) sodium feldspar.

The white-firing ceramic masses were composed of kaolin, a plastic material and a non-plastic material with a white base, as indicated in Table (3). Figure 3 (a), (b), (c), (d) and (e) show the vitrification curves of the five samples. These curves are the tools that allow evaluation of the water absorption and linear shrinkage parameters as a function of the expressed temperature[4]. The data enable determination of the best firing temperature and tile properties.

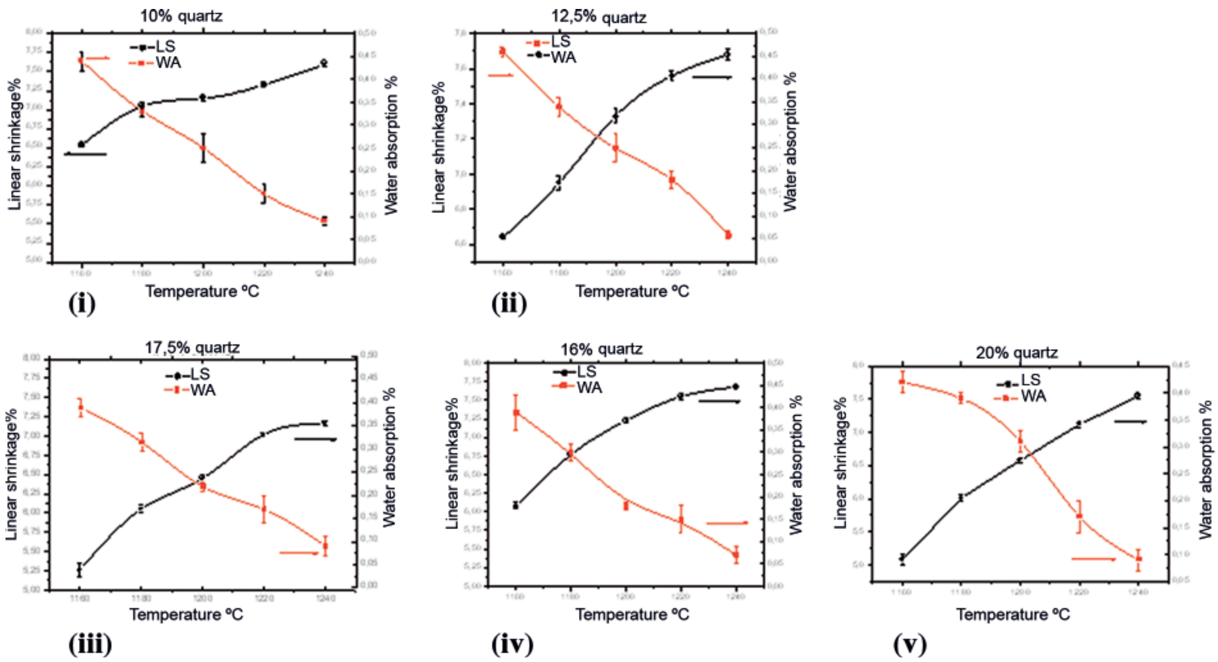

Figure 3. Vitrification curve (i) M1, (ii) M2, M3 (iii), M4 (iv), M5 (v).

The study of the influence of quartz content on the water absorption and linear shrinkage properties was made by comparing all the prepared ceramic masses, M1

(10% quartz), M2 (12,5 % quartz), M3 (15% quartz), M4 (17,5% quartz) and M5 (20% quartz), at all test temperatures.

Table 4 gives the results obtained after the modulus of rupture analysis as a function of the temperature and the quartz content used. The bodies prepared with the different masses display values that are within those specified in Table 1. It is observed that as temperature increases the modulus of rupture also increases; however these increases occur in detriment to the quartz content used. This is attributed to the reduction in plasticity when the quartz quantity is increased.

MASS	TEMPERATURE (ºC)				
	1160	1180	1200	1220	1240
	MODULUS OF RUPTURE (MPa)				
M1	44,83±3,84	45,30±3,11	46,39±4,04	47,56±3,62	47,87±4,02
M2	42,24±3,73	42,54±2,38	42,89±2,65	44,68±2,53	45,03±6,40
M3	42,10±2,32	42,50±2,87	43,22±2,26	43,27±2,70	45,11±3,73
M4	36,13±2,99	38,21±3,81	39,35±2,34	40,19±3,98	42,28±1,55
M5	36,11±1,36	36,81±1,91	37,23±1,75	37,30±1,42	38,73±1,97

Table 4. Modulus of rupture in the formulations of the prepared masses.

4. CONCLUSIONS

The ceramic mass processed with raw materials from the State of Rio Grande do Norte demonstrates a great potential.

The raw materials kaolin, sodium feldspar and quartz from the State of Rio Grande do Norte display an adequate mineralogical composition for processing ceramic tiles of the porcelain tile type.

The values of the mechanical strength and water absorption obtained demonstrate that the sintered ceramic bodies are within the values established by standard NBR 13818.

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