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Effect of flux content and heating rate on the microstructure and technological properties of Mayouom (Western-Cameroon) kaolinite clay based ceramics

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ABSTRACT

Four mixtures of kaolinite clay and feldspar (Western-Cameroon) were prepared and sintered at 1200 °C for 2 h at the heating rate of 5 °C/min, 10 °C/min, 15 °C/min and 20 °C/min. The main new crystalline phase was mullite associated with quartz, anatase and cristobalite for all heating rates. By increasing the feldspar content, both the amounts of mullite and of glassy phase increase which promotes the densification of the samples. Heating rate has less influence on the formation of new mineral phases, while this process is sensitive to flux content. Both heating rate and flux content have an effect on the microstructure of the fired bodies as well as technological properties. The specimens with 30% feldspar content sintered at 1200 °C from 5 °C/min to 20 °C/min exhibited water absorption values <10% and bending strength >12 MPa. These materials are suitable as wall tiles. Thus, these samples can be sintered at a heating rate of 20 °C/min instead of 5 °C/min which leads to a saving in firing time and in energy.

1. Introduction

Technological properties of clay based ceramics depend on the characteristics of the raw materials: mean particle size distribution, plasticity, chemical and mineralogical compositions as well as firing conditions such as temperature, soaking time, heating rate and firing atmosphere [1–5]. To improve the production, ceramic manufacturing requires the reduction of production costs, especially the energy costs. This may be achieved by adopting fast firing cycles and using fluxes. Many studies on the use of fluxing agents in the production of ceramic products for reducing the firing temperature have been reported [6–10]. For the firing cycle, there is also much literature on the effect of temperature and soaking time on the ceramic properties [11–14]. Less attention has been paid to the effect of heating rate [15,16]. Thus, in this study, a particular attention was paid to the effect of flux content and heating rate on the microstructure and on some technological properties of a clay-based ceramic material. On the other hand, it may be mentioned that, among the technological properties, water absorption, firing shrinkage and bending strength are the most commonly measured characteristics in the evaluation of the performance of ceramic products [17,18]. In addition to its fundamental aspect, this study may help to valorize the kaolinite clay deposit of Mayouom (Cameroon) [19–21].

2. Materials and experimental methods

Kaolinite-rich clay, labelled MY4, and a feldspar-rich material (F1) from Mayouom and Dschang (Western-Cameroon), respectively, were used as raw materials for the studied blends [20,22]. Their chemical and mineralogical compositions are given respectively in Tables 1 and 2. Four mixtures of raw materials denoted respectively FO0, F01, F02 and F03 were prepared and their compositions are given in Table 3. Suspensions of the mixtures were prepared and oven dried (105 °C) till constant mass was achieved (~24 h). The dried mixtures were ground and sieved (100 μm). For each formulation, a cylindrical test piece (7 × 6 × 6 mm) for water absorption and a rectangular prism test piece (80 mm × 42 mm × 8 mm) for flexural strength and firing shrinkage evaluation were obtained by compressing, at 30 MPa,

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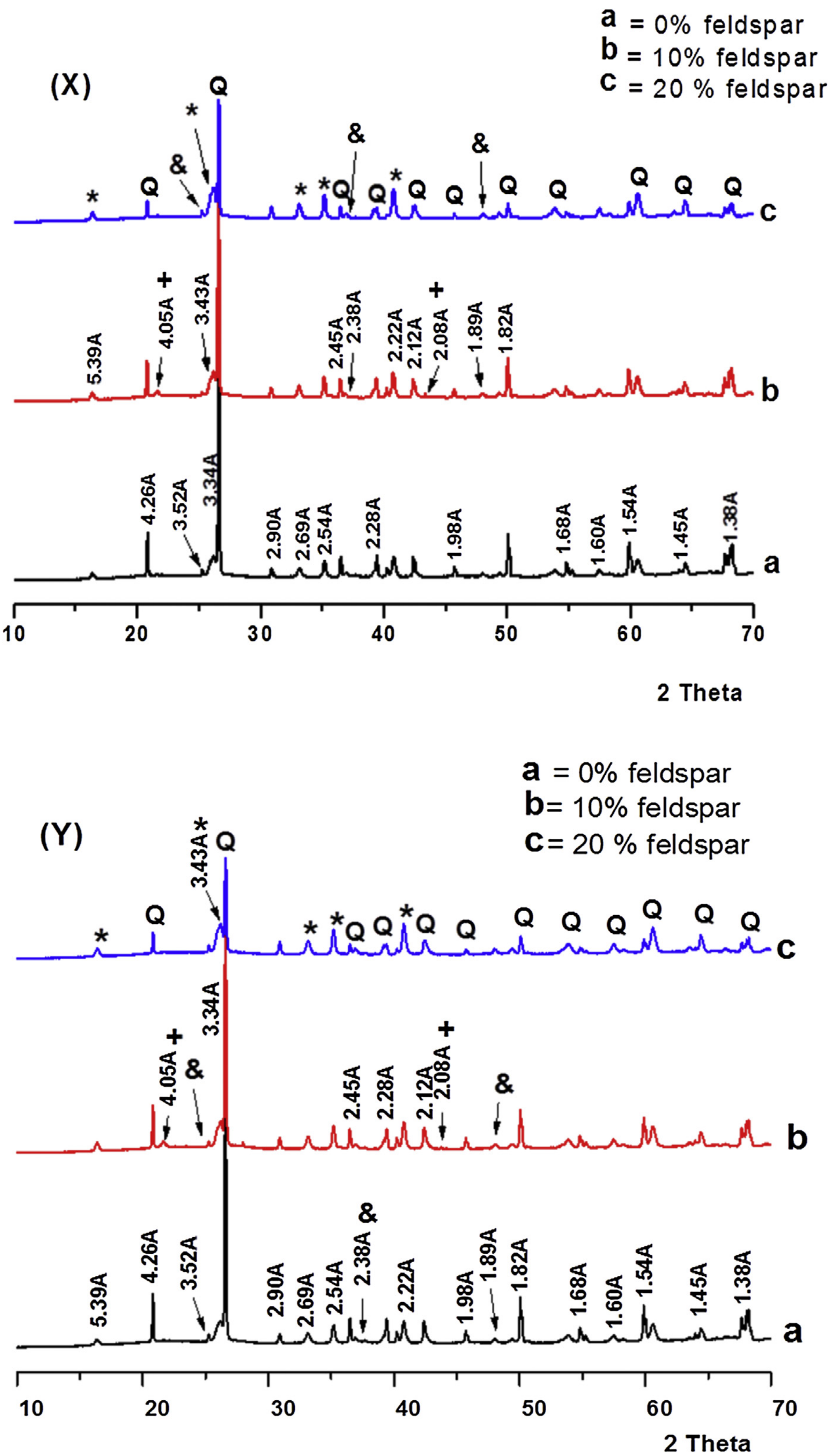

Fig. 1. X-ray diffraction pattern of the fired product (X) at 5 °C/min and (Y) 20 °C/min. *: mullite; Q: quartz; +: cristobalite; &: anatase.

Table 1
Chemical composition of the used raw materials (Wt.%).

	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	K_2O	Na_2O	CaO	MgO	P_2O_5	MnO	LOI	Total
MY4	63.02	25.79	0.16	0.94	0.87	<ld	<ld	<ld	0.16	<ld	8.89	99.83
F1	67.61	19.00	0.15	0.01	6.95	5.38	1.19	0.02	<ld	<ld	0,49	100.2

LOI: loss on ignition.