USE OF SPODUMENE FOR MANUFACTURING PORCELAIN TILE BODIES OF HIGH WHITENESS

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1. INTRODUCTION

Spodumene is a lithium aluminosilicate, which belongs to the pyroxene group and is widely used in the ceramic industry as a flux (ceramic tiles, sanitary ware, etc.). The largest deposits of this mineral are located in Western Australia, where they are mined by the firm Sons of Gwalia LTD.

This study addressed the use of spodumene for producing porcelain tile bodies commonly known as "superwhites". In general, these bodies are formulated with appreciable percentages of kaolin in order to achieve a very white colour in firing; however, the use of these raw materials usually entails certain drawbacks:

- The refractoriness of the body increases. In fact, bodies of high whiteness usually have a firing temperature 5-10 °C higher than that of the base bodies formulated without kaolin.
- Tile linear shrinkage increases during firing. This is due to poor compaction and high loss on ignition of the kaolins.
- Body opacity increases, as these raw materials contribute a high alumina content, with the ensuing reduction in colour development capacity.

The use of spodumene was therefore studied in the present work with a view to producing bodies of high whiteness without requiring the use of kaolins. These bodies would need to have a similar firing temperature and linear shrinkage to those of the base bodies; furthermore, due to their low alumina content, they would need to allow easy pigmentation.

2. MATERIALS AND EXPERIMENTAL DEVELOPMENT

Two typical porcelain tile bodies were prepared: a *base* (C1) and a *superwhite* (C2). A porcelain tile body (C3) was also developed and prepared of a similar whiteness to that of body C2, but whose behaviour in pressing (bulk density), optimum firing temperature and linear shrinkage at this temperature more closely resembled that of body C1. The C3 composition was formulated without kaolin, using U.G.S. spodumene, which contained about 6% Li_2O. Table 1 presents the compositions and chemical analysis of these bodies.

	C1	C2	C3
Clay	42.5	20	30
Feldspar	47.5	50	40
Kaolin	-	20	-
Sand	10	10	27
Spodumene	-	-	3
SiO_2	70.2	67.3	73.5
Al_2O_3	19.2	21.4	17.0
Fe_2O_3	0.47	0.31	0.30
TiO_2	0.59	0.39	0.48
Na_2O	4.7	5.1	3.9
K_2O	1.4	1.0	1.2
Li_2O	-	-	0.18

Table 1. Composition and chemical analysis of the studied bodies.

Disk-shaped test specimens were made from the bodies at 400 kg/cm^2 and a moisture content of 5.5% (dry base). After drying, the test specimens were fired at maximum firing temperatures (1190, 1200, 1210 and 1220 °C) for 6 minutes, then determining linear shrinkage, water absorption, bulk density on firing and chromatic co-ordinates of the specimens. These data were used to estimate the optimum maximum firing temperature for each body (temperature slightly exceeding maximum densification temperature), as well as the properties of the product fired at this temperature.

Moreover, in order to determine the effect of the composition on the colour development capacity, 5% zirconium silicate and 1% blue pigment were added to the three test bodies. These were then pressed according to the procedure set out above, the resulting test specimens were fired at the optimum firing temperature, and finally, their chromatic co-ordinates were determined.

3. RESULTS AND DISCUSSION

Table 2 summarises the outcomes.

Analysis of these results shows that body C3 exhibits bulk density, firing temperature and linear shrinkage data on firing very similar to those of base body C1, so that its behaviour during the different manufacturing process stages will resemble that of this last type of body.

In contrast, the whiteness of this body and its colour development capacity are similar and even higher than those of high whiteness body, C2. Thus, the addition of 1% blue pigment yields more negative co-ordinate b* values for body C3, indicating greater development of this colour. As far as whiteness is concerned, the co-ordinate L* value corresponding to body C3 is lightly higher than that of body C2, both before and after adding zirconium silicate.

Property	Body C1	Body C2	Body C3
Dry bulk density	1.85	1.82	1.84
Firing temperature	1205	1215	1204
Linear shrinkage	8.9	9.3	8.8
Co-ordinate L*	73.5	80.0	80.1
Co-ordinate a*	2.5	2.0	1.6
Co-ordinate b*	12.4	11.0	11.2
Co-ordinate L* (+5% zirconium)	79.5	85.0	85.2
Co-ordinate b* (+1% blue pigment)	-8.7	-16.5	-17.0

Table 2. Results.

4. CONCLUSIONS

The present study addressed the use of spodumene in producing bodies of high whiteness without using raw materials with a high alumina content.

The increased refractoriness stemming form the use of a very high percentage of feldspathic sand, which is the ingredient with least alumina in the composition, was compensated by the addition of a small percentage of U.G.S. spodumene.

The results show that the developed body behaves similarly to the base body during the different manufacturing process stages. In contrast, the developed body's whiteness and colour development capacity more closely resemble and even exceed those of the common *superwhite* body.

The characteristics of the proposed body, unlike those of current bodies which are usually designed for one or more concrete applications, are therefore suitable for achieving the different surface effects and decorations sought in the production of technical porcelain tile.