TOUGHNESS MEASUREMENT IN CERAMIC GLAZES

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1. INTRODUCTION

Toughness is a parameter that indicates a material's capacity to withstand sudden crack propagation. Given the importance of knowing how ceramic glazes behave with regard to crack formation and extension, a method for measuring this property has been designed, based on the procedure used for the so-called technical ceramics [1] [2].

2. MATERIALS USED AND EXPERIMENTAL PROCEDURE

The toughness tests were carried out on the following types of glazes: transparent glazes with a high lead content, transparent, glossy white and glass-ceramic glazes.

First of all, the glaze surface was polished on which the indentation tracks were to be made. This was done by cutting off test specimens from tiles that had been coated with the glazes that were to be studied. These test specimens were the embedded in an epoxy resin, and the glaze surfaces were polished using progressively finer abrasive grain, until finally polishing with diamond paste having a mean grain size of 3μm.

Indentation testing was carried out using a hardness tester with a Vickers indenter, capable of working at loads ranging from 1-50 kg. The necessary load was used for each glaze (holding this for 15 s), which yielded suitably sized cracks. The test specimens were placed in the hardness tester in such a way that the perfectly clean, polished surface lay at right angles to the indenter axis. As many indentations were performed on each test specimen as were needed to obtain at least ten specimens whose cracks and diagonals met the required conditions.

An image analyzer connected to an optical microscope was then used to determine the length of the two diagonals of the selected tracks. In order to obtain a sharper image, the test specimens were subsequently etched using a hydrofluoric acid solution at a concentration of 2.5% by volume, washing the specimens immediately afterwards with distilled water to remove acid rests. The length of the cracks was then measured, using the image analyzer.

In order to calculate the toughness of these glazes, it was necessary first to measure the microhardness and modulus of elasticity of these test specimens.

The microhardness values were obtained from the length of various track diagonals, made with a Vickers punch to which a load of 200 g had been applied for 15 s.

The moduli of elasticity were calculated from the data supplied by a microhardness tester, which recorded the values of the depth reached by the indenter during its entrance and exit in testing, as a function of the applied load at each moment, up to a maximum load of 100 g.

These data then allowed toughness to be calculated, by means of the following equation [1]:

$$K_{Ic} = 0.016 \cdot (E/H)^{0.5} \cdot P \cdot c^{-1.5}$$

where: K_{Ic} = toughness ($MPa \times m^{1/2}$); H = Vickers microhardness (GPa); E = modulus of elasticity (GPa); P = load applied to the indenter to produce cracks (N); c = distance from the centre of the track to the end of the crack (μm)

3. RESULTS AND DISCUSSION

Table 1 lists the microhardness, modulus of elasticity, crack mean length and toughness values found for the studied glazes:

Table 1. *Experimentally obtained toughness values.*

Glaze	H (GPa)	E (GPa)	c (μm)	K_{Ic} ($MPa \times m^{1/2}$)
Transparent lead	4.2±0.1	67±2	37.8	0.5±0.1
Transparent	5.7±0.1	86±1	72.4	1.0±0.1
Glossy white	5.6±0.1	97±1	162.0	1.6±0.2
Glass-ceramic	6.1±0.1	99±3	92.2	3.6±0.3

Table 2 sets out the toughness values reported in the literature [1] [3] for materials having a similar nature to the studied glazes.

Table 2. *Toughness values reported in the literature.*

Material	KIc ($MPa \times m^{1/2}$)
Lead glass	0.4 - 0.7
Aluminosilicate	0.8 - 1.1
Glass-ceramic	2.5

On comparing the values of Tables 1 and 2, it can be observed that the toughness values obtained for materials of a similar chemical nature are of the same order. This fact confirms the validity of the technique used for measuring the toughness of ceramic tile glazes.

4. REFERENCES

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