INFLUENCE OF COMPOSITION AND FIRING TEMPERATURE ON PHYSIO-MECHANICAL PROPERTIES OF A KENYAN TRIAXIAL (QUARTZ-FELDSPAR-KAOLIN) PORCELAIN

by

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CERTIFICATION

The undersigned certify that he has read and hereby recommend for acceptance by the University of Nairobi a thesis titled: ***Influence of Composition and Firing Temperature on Physio-mechanical Properties of a Triaxial (Quartz-Feldspar-Kaolin) Porcelain***, in fulfillment of the requirements for the degree of Doctor of Philosophy (Physics).

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DECLARATION

I, Francis Wanjala Nyongesa, declare that this thesis is my own original work and that it has not been presented and will not be presented to any other University for a similar or other degree award.

Signature: .....

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ABSTRACT

In this study, the effect of composition and sintering temperature on material properties (physical and mechanical) of porcelain composed of 0–50 wt% silica, 10–70 wt% kaolin and 20–50 wt% feldspar have been investigated. The effect of pore and crystalline phases on the mechanical behaviour (both elastic modulus and the flexural strength) has been assessed. Additionally, models based on the pore shape-stress concentration and the minimum solid-area have been analyzed for their contribution in the mechanical behaviour of porcelain materials.

Optimal sintered density and material strength were obtained at 1150 °C with body composition of 20 wt% silica and a feldspar-to-kaolin ratio of 5:8. The propagation of ultrasonic waves was significantly influenced more by pore sizes than by the shape of the pores. Formation of secondary mullite increased the strength of porcelain by its interlocking effect due to the smaller needle diameter. The circumferential cracks around quartz grains caused by the large expansion accompanying α- to β-quartz transformations and vice versa at 580 °C decreased the strength of porcelain.

The decrease in porosity was found to be the predominant factors contributing to improvement of mechanical strength (both Young's modulus and modulus of rupture). It is proposed that for all practical purposes, the analytical relations obtained in the present work for the ultrasonic longitudinal velocity (V_l)-volume porosity (P), Young's modulus (E)-volume porosity (P) and the modulus of rupture (σ)-volume porosity (P) relationships can be effectively approximated by empirical relations of the form $V_l = V_o(1-P)^x$, $E = E_o(1-kP^{2/3})$

and $\sigma = \sigma_o exp(-bP)$ respectively. The subscript zero refers to the material of theoretical density and x, k, and b are fitting parameters.

A better prediction ability of the Young's modulus-porosity relationship was obtained by taking into account the pore character (shape and orientation) and using a variable aspect ratio 'α' (at narrow ranges of porosity). The self-consistent scheme theory was not best suited for use in multiphase materials like porcelain. Finally, within the porosity range of ($0.075 < P < 0.41$), the stress concentration model predicts better the mechanical behaviour on porcelain compared to the minimum-solid area model.