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Utilization of Nano-Hydroxyapatite in the Fabrication of Ceramic Bodies with Enhanced Mechanical Properties and Translucency

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KEYWORDS

Bone China, Fish Bone Recycling, Calcium Phosphate, Mechanical Properties, Whitening, translucency.

SHORT SUMMARY

Fish industry produces a huge quantity of wastes, especially fish bone. Such wastes are considered as one of the most annoying problems. In the present study, hydroxyapatite [HAp] powder was extracted and produced in nano scale from fish bone to fabricate bone China ceramic bodies. Bone China bodies with different compositions were designed. The physical, structural, mechanical, thermal, and technical properties of the prepared bodies were evaluated. The effect of the use of bone ash in the fabrication of bone China bodies was estimated. Results revealed that bone China bodies are composed of anorthite, ß- tricalcium phosphate and quartz. The increase in ß- TCP crystalline phase leads to the enhancement of coefficient of thermal expansion values. The introduction of bone ash into the batches formula improved the mechanical strength, enhanced the expansion coefficients and increased both the bodies' whiteness and translucency.

EXTENDED ABSTRACT

Introduction

Recycling is the best environmental solution to save raw materials and to reduce the amount of industrial waste materials produced, and consequently the contamination of environment. In ceramic industry wastes may be used to replace conventional starting materials, with the advantage of controlling the plasticity and shrinkage of the ceramic body without producing any negative effect on the product properties, and allowing sintering at low temperatures, thus resulting in energy conservation.

Bone China is the world's most expensive type of tableware. In addition, it has the most remarkable mechanical strength compared to any pottery body. Bone China properties are strictly dependent on the quality of the raw materials used to fabricate their bodies. The selection of raw materials and their proportions particularly the bone ash, and processing parameters have a strong influence on the development of the microstructure.

Bone China bodies possess a short firing range due to their high content of fluxes. There are many factors controlling the translucency of unglazed bone China. First, the firing speed which is an important factor that should be taken into consideration. Firing at low speeds increases the body's translucency. Also, firing temperature and soaking time are important parameters in controlling the translucency of the unglazed bone China wares [1-2].

HAP is responsible for the whiteness and the semi-transparent characteristics of bone China bodies. Fish-bone ashes have a unique microstructure, because they are a complete replica of fish bone but have a relatively dense wall. Ozawa and Suzuki [3] detected that when the fish bone is heated at temperatures about 1300 ˚C, it maintains the porous structure with a sintered wall of the major crystalline phase of hydroxyapatite. Accordingly, four batches of bone China compositions containing fish bone ash were designed and studied.

Methodology

Bone China ceramics with high mechanical and

translucence properties were prepared from natural resources namely, fish bones, kaolin and feldspar. The preparation method based on two phases:

Phase I: Preparation of pure nano-hydroxyapatite powder from fish bones, fig. 1.

Phase II: Mixing the hydroxyapatite powder obtained from the fish bones with pure Kaolin and pure feldspar with different percentage (Table 1). The obtained mixture was pressed using the semi-dry method and then fired at a temperature of 1225 ºC to obtain the bone China ceramics.

Batch symbol	Fish bone ash, %	E.C.C Kaolin, %	Weathered feldspar
BC_1	50	25	25
BC_2	45	25	30
BC_3	40	25	35
BC_4	35	25	40

Table 1. Mixing the hydroxyapatite powder from fish bones with pure Kaolin and pure feldspar

The physical, structural, mechanical, thermal, and technical properties of the prepared bodies were evaluated. Results revealed that bone China bodies are composed of anorthite, ß- tricalcium phosphate and quartz, fig. 2. The increase in ß- TCP crystalline phase leads to the enhancement of coefficient of thermal expansion values.

The prepared bone China ceramics prepared from fish bones are characterized by its high translucency (28 %), low porosity (less than 1.9 %) and high mechanical properties (74.97 MPa). The bodies possess a moderate thermal expansion coefficient of 6.44 × 10^{-6} K^{-1} (Table 2).

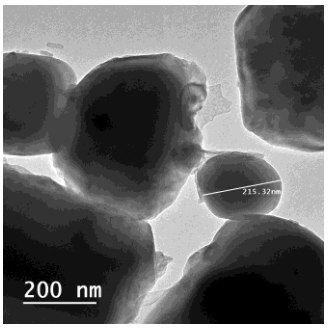

Fig. 1. TEM images of nano-hydroxyapatite.

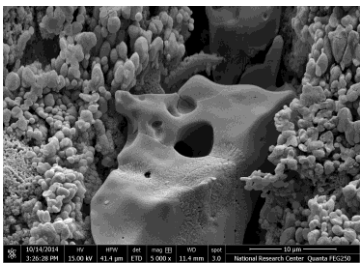

Fig. 2. SEM image showing the cracked and fragmented quartz grains.

Batch symbol	TEC x 10^{-6} K^{-1} (25–600 C)	Bending strength / MPa	Transluceny %	Bulk Density	Apparent porosity
BC_1	6.33	40.39±1.97	23.9	2.5	5.14
BC_2	6.44	74.97±6.48	28	2.39	1.9
BC_3	6.50	75.08±2.83	21.5	2.56	1
BC_4	6.67	75.28±6.08	24	2.34	2.35

Table 2. Physical, thermo-mechanical and translucency results of the four batches of the fabricated bone China ceramic bodies.

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