USE OF A SUSTAINABLE ZnO IN PLACE OF STANDARD ZnO IN CERAMIC TILE PRODUCTION

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1. SUMMARY

This study was carried out in order to investigate the possible use of ZincOx's Industrial Zinc Oxide (IZO) in ceramic frits. The IZO sample was generated at laboratory scale by a new sustainable and environmentally friendly upgrading process of HZO (Halide Bearing Zinc Oxide) concentrate. HZO is industrially produced in South Korea from the recycling of EAFD (Electric Arc Furnace Dust) by using ZincOx's Rotary Hearth Furnace technology. First of all, the chemical, mineralogical and physical properties of the IZO and a standard ZnO provided commercially were measured. Several transparent and opaque frit formulations containing sustainable and commercially available ZnO powders in varying amounts were then prepared under laboratory conditions. From these frits, transparent, opaque and matt wall tile glazes were formulated and prepared at laboratory conditions. Glazes were applied to already engobed wall tiles and fired under standard industrial firing conditions. The physical, mineralogical and colour properties of the fired bodies were measured. Scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDX) were further employed in order to observe the microstructural and micro chemical characteristics of the fired bodies. The experimental results showed that it was possible to employ IZO in place of the commercially available standard ZnO. No difference in qualities was observed between the different ceramics produced with the IZO and a zinc oxide usually used in the ceramic industry.

Sustainable zinc oxide powder was produced by the laboratory upgrading of HZO (Halide Bearing Zinc Oxide). HZO concentrate was taken from the recycling of EAFD (Electric Arc Furnace Dust) by using ZincOx's Rotary Hearth Furnace technology First of all the chemical, mineralogical and physical properties of ZincOx-IZO and a standard ZnO provided commercially were measured. Then, several transparent and opaque frit formulations containing IZO and commercially available ZnO powders in varying amounts were prepared under laboratory conditions. From these frits, transparent, opaque and matt wall tile glazes were formulated and prepared at laboratory conditions. Glazes were applied to already engobed wall tiles and fired under standard industrial firing conditions. The physical, mineralogical and colour properties of the fired bodies were measured. Scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDX) were further employed in order to observe the microstructural and micro chemical characteristics of the fired bodies. The experimental results showed that it was possible to employ ZincOx-IZO in place of commercially available ZnO in frits and glazes with similar properties.

Standard tests (-EN 10545 standard tests-) were applied on glazes made with commercially available ZnO and with ZincOx-IZO. No significant difference was observed between the different glazes. The experimental results showed that, in frits and glazes, ZincOx-IZO can replace the commercial zinc oxide normally used in these applications.

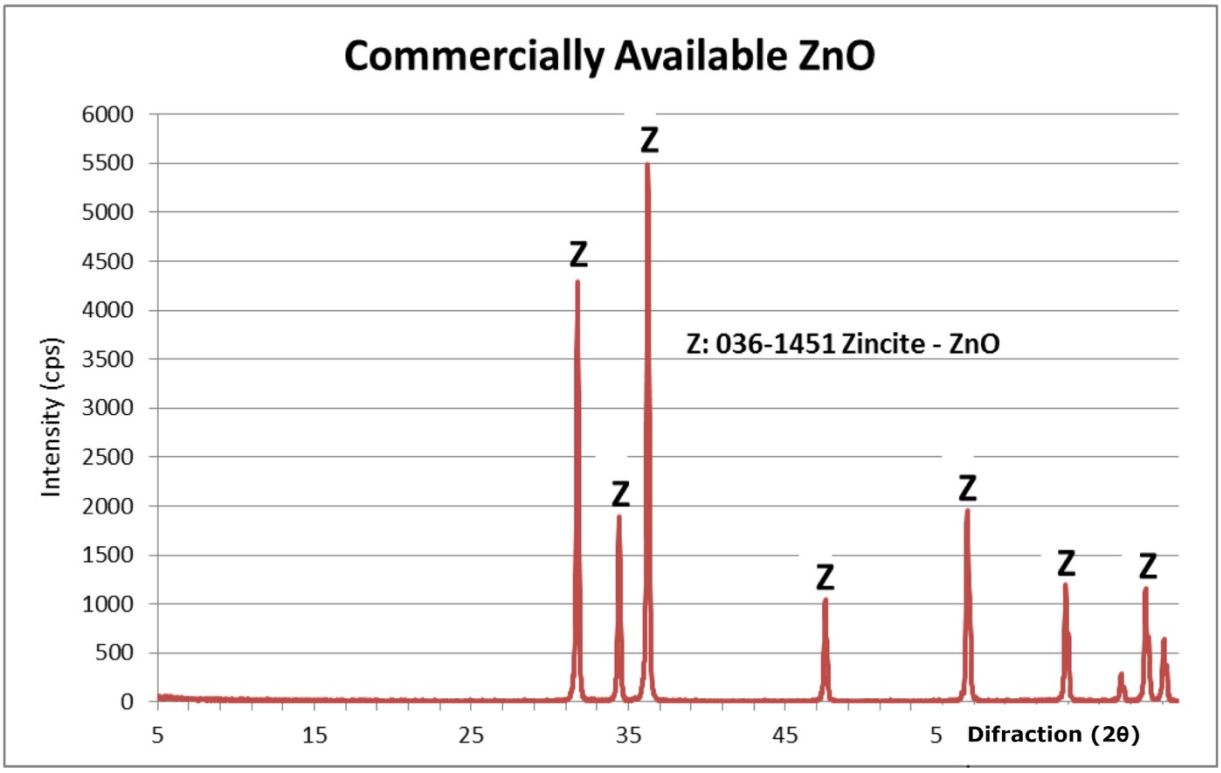

Figure 1: *Representative XRD spectra of a commercially available ZnO.*

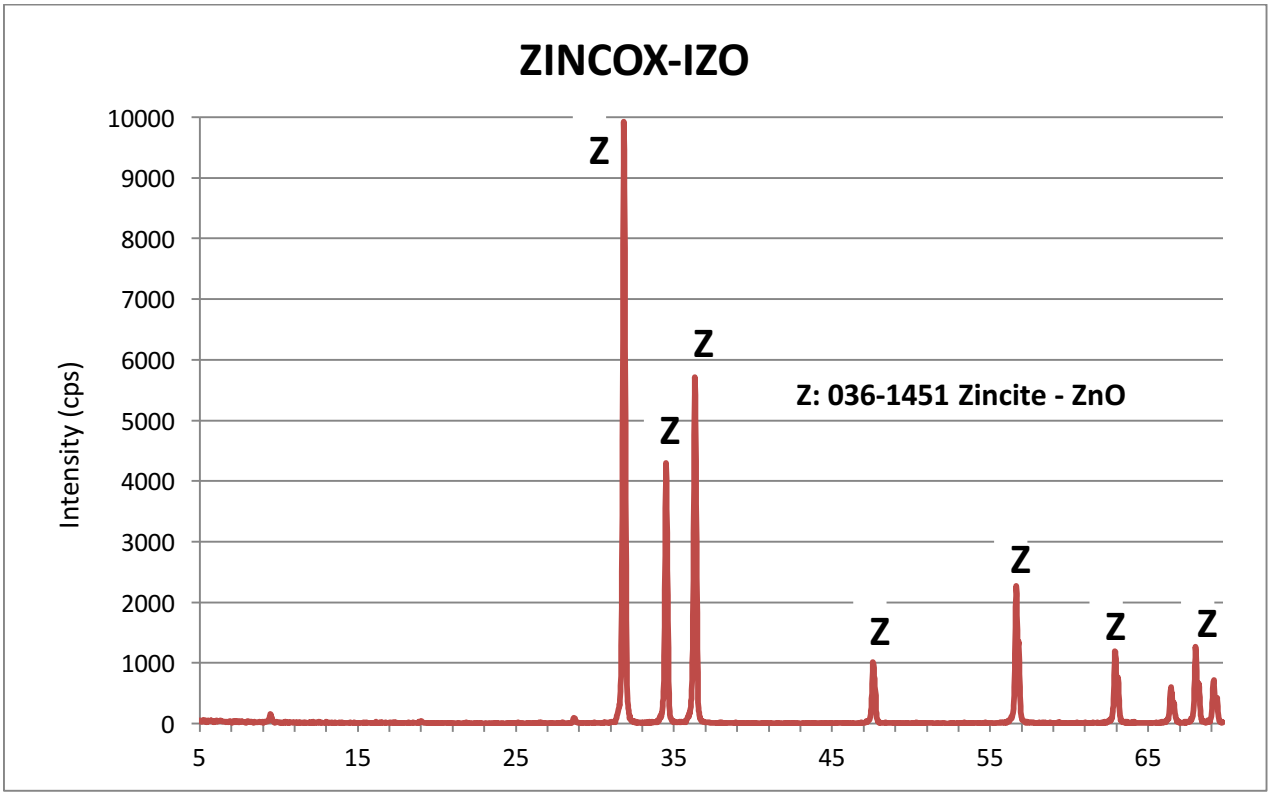

Figure 2: *Representative XRD spectra of ZINCOX-IZO ZnO.*

	ZINCOX-IZO wt. (%)	COMMERCİALLY AVAİLABLE ZnO wt. (%)
SiO_2	0.216	0.187
CaO	0.035	---
Cr_2O_3	0.047	---
Fe_2O_3	0.191	0.206
ZnO	99.397	99.427
PbO	0.087	---
SO_3	---	0.070
L.O.I.	0.027	0.110

Table 1: *XRF of the ZnO powders*

RAW MATERIAL (wt. %)	TRS.* STD	TRS.* ZincOx IZO	OPAQUE STD	OPAQUE ZincOx IZO
QUARTZ	32.0	32.0	49.5	49.5
ALUMINA	2.0	2.0	4.0	4.0
K-FELDSPAR	25.0	25.0	1.5	1.5
K-CARBONATE	4.5	4.5	4.5	4.5
CALCITE	14.5	14.5	13.5	13.5
DOLOMITE	6.0	6.0	10.0	10.0
COMMERCİALLY AVAİLABLE ZnO	7.0	---	11.0	---
ZINCOX-IZO	---	7.0	---	11.0
BORIC ACID	7.5	7.5	---	---
BORAX	1.5	1.5	---	---
ZIRCON	---	---	6.0	6.0
TOTAL	100.0	100.0	100.0	100.0

Table 2: *Frit compositions*

**) Transparent*

	TRS.* STD GLAZE	TRS.* ZincOx IZO GLAZE	OPAQUE STD GLAZE	OPAQUE ZincOx IZO GLAZE	MATT STD GLAZE	MATT ZincOx IZO GLAZE
L	89.07	89.48	93.99	93.54	94.69	94.32
a	0.89	0.65	- 0.14	-0.05	0.08	0.11
b	0.55	0.52	1.11	1.41	1.58	1.66

Table 3: *Chromatic coordinates of the glazes (L, a, b)*

**) Transparent*

	TRANSPARENT STD	TRANSPARENT ZincOx IZO	OPAQUE STD	OPAQUE ZincOx IZO
Sintering temperature (° C)	872	878	920	904
Softening temperature (° C)	994	1010	1084	1088
Sphere temperature (° C)	1048	1050	1114	---
Half Sphere temperature (° C)	1116	1104	1166	1128
Melting temperature (° C)	1184	1138	1228	1148

Table 4: *Thermal behaviour of the glazes*

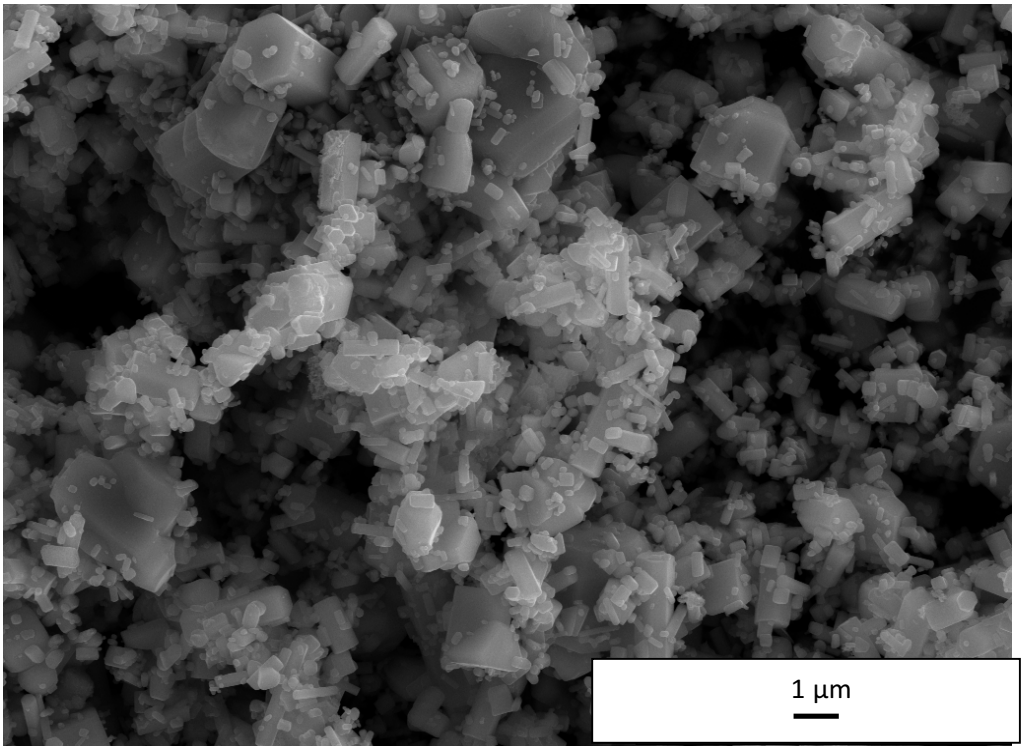

Figure 3: *Typical SEM image of the ZincOx IZO powder (15000 X)*

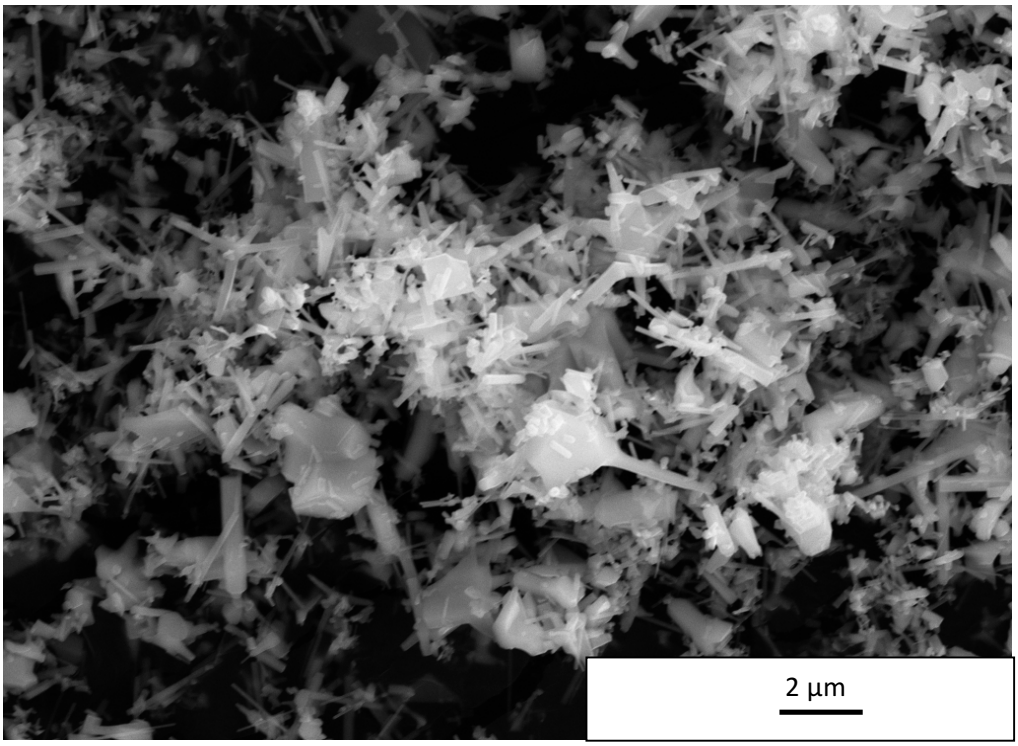

Figure 4: *Typical SEM image of the standard ZnO powder (15000 X)*