Production of Enamel Stains from Igbokoda Silica Sand

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ABSTRACT
Silica sand was sourced from Igbokoda, ondo state, this was washed, dried and the percentage clay and organic matter present in the silica sand determined. Some percentage of the silica sand was used to compose different batches of enamel compositio and was fired to a temperature of 1200^{o}C. The compositions were fritted in metallic bucket and then pulverized to form powder. The powder was mix with gum arabic to form a paste and this was used to print on ceramic wares and glass cups. The printed wares were tested to determine the resistance of the wares to acid and base environment. From the test, the result showed that the enamel produced exhibit a good resistance to acid and base.
Keywords: Enamel, frits and Igbokoda silica

Introduction

Silica sand is one of the most common mineral in the Earth Crust. It is made up of broken quartz crystals which has been broken down into tiny granules over years through the action of water and Weathering (Edem, 2014). Silica sand granules can be used for different purpose such as glass production, glass stains, enamel production and this is found deposited in most non tropical region of the world (Carr,1971;Hecketal,2002;Freestone,2005). In Africa, especially in Nigeria silica sand deposit are mostly found deposited in most parts of the country particularly in riverin ,estuaries and beaches(Chang, 1991; Claude, 2002;Malu and Bassey,2003). One of the major deposit of silica sand in Nigeria is Igbokoda.

Igbokoda is located in Ondo state . It has a river which is one of the major and important river in Nigeria which lies on latitude 4^{o}.40-5^{o}.00N and 6^{o}.00-60-20E. The river is noted for artisanal fishing activities, transportations and mining of silica sand (Olaniyan, 2016). The mineral resources department of Ondo state estimated that Ondo state silica sand has an estimated reserve of 3 billion MT where igbokoda is one of the principal location for the silica sand. Igbokoda silica sand is available for commercial exploration and exploitation for the production of glass and ceramic production. Igbokoda silica has been characterized by Ojuri 2015 to have about 94.24% SiO_2 content, this is an evident of a good silica for glass industries.

Research Objectives

i access Igbokoda silica sand for enamel stain composition.
ii vary the different composition with metallic oxides.
ii frit the various batches at melting temperature of the metallic oxides
iii Pulverise the melted batch
iv. mix the pulverized sample with mixing agent
v examine he effect of the enamel produced wares at 600-700^{o}C firing temperature;
vi test the enamel produced to determine the resistance to acid and base.

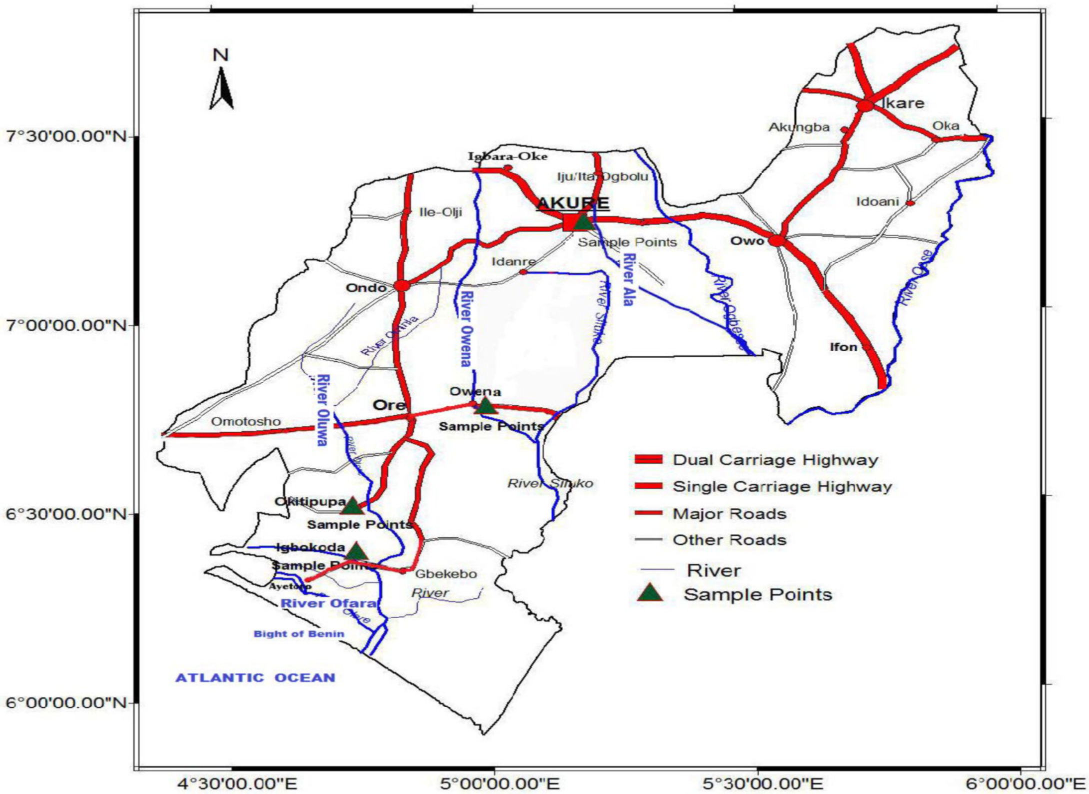

Fig. 1 Hydrological network within study area (Ondo State) showing where samples were taken (Adapted from Federal Surveys)

Materials and Equipment

Washing and water bowl: This is a container used for holding materials e.g water or wet materials.

Pulverizer: This is used for the reduction of materials to a powdery form.

Kiln: The kiln is used for heating in the ceramic studio. This is used to fire to the required temperature before fritting

Screen/Mesh : This is used to transfer designs on the surface of the glass and ceramic wares.

Weighing balance(Electronic): A weighing balance allows to determine the mass of various materials used for the experiment.

Crucibles: These are used to hold materials to be fired. It is a refractory material that can withstand a very high temperature of above 1200^{o}C.

Design : This is the printed on the glass and ceramic surface which is in form of logo or art work. This is done with the use of the computer.

Silica Sand: The silica sand is the major raw material required for the stain production. It is the glass former hence increases the mechanical strength of the stain and gives the stain a higher

Ceramic metallic oxides : These are the oxides that are responsible for the various types of colourations in stains.

Mixing agent: This is the medium that allows the enamel to flow so that it will be able to stay on the printed material.

Auxilliary materials: These are the other raw materials added to the composition to aid the melting process.

Methods

Flow chart of the production process.

Washing
↓
Drying
↓
Milling
↓
Mixing
↓
Melting
↓
Fritting
↓
Grinding
↓
Mixing
↓
Application using the mesh (screen printing)
↓
Reheating

PROCEDURE

The samples of the silica sand was gotten from the site, these were poured in a bowl and washed using water. This is done in order to remove the impurities that might be present in the silica sand from the deposit, it was then air dried and stored in a sack.

The silica sand was weighed and combined in various ratios with other fluxes, opacifiers and metallic oxides respectively. The fluxes, opacifiers and the metallic oxides were to reduce the melting temperature of the silica sand, make the enamel stain translucent and to add colourants respectively. The samples were weighed in different proportion according to the tables below and then poured into different crucibles and fired to a temperature of 1200^{o}C in a muffle kiln. At that temperature, most of the batches had form glass. The various crucibles were removed from the kiln and poured differently into an Iron container in order to frit the composition.

The various fritted batches were then put in a pallet and labeled accordingly. The pallets were later taken to the workshop to pulverize the samples so as to have a powder form of the frit.

The powder was mix with gum arabic for it to form a paste, the paste was necessary so that the enamel stain produce can stick to the body of the glass and ceramic wares. Various tests were then carried out on the wares to know the acid and base resistant of the enamel produced.

Table 1

Composition A1

Oxides	Percentage Composition	Weight in Gramme
Silica sand	15%	75g
Feldspar	10%	70g
Calcium Oxide	8%	40g
Zirconium Oxide	5%	25g
Sodium Oxide	44%	220g
Cullet	14%	70g
Iron Oxide	4%	10g
	100%	500g

Table 2
Composition B2

Oxides	Percentage Composition	Weight in Gramme
Silica sand	20%	100g
Feldspar	9%	70g
Calcium Oxide	8%	40g
Zirconium Oxide	5%	25g
Sodium Oxide	40%	220g
Cullet	14%	70g
Cobalt	4%	10g
	100%	500g
Chromium	2%	10g
	100%	500g

Table 3
Composition A2

Oxides	Percentage Composition	Weight in Gramme
Silica sand	15%	75g
Feldspar	10%	70g
Calcium Oxide	8%	40g
Zirconium Oxide	5%	25g
Sodium Oxide	44%	220g
Cullet	14%	70g
Manganese oxide	4%	10g
	100%	500g

Table 4
Composition B2

Oxides	Percentage Composition	Weight in Gramme
Silica sand	20%	100g
Feldspar	9%	70g
Calcium Oxide	8%	40g
Zirconium Oxide	5%	25g
Sodium Oxide	40%	220g
Cullet	14%	70g
Copper oxide	4%	10g
	100%	500g

Table 5
Composition A3

Oxides	Percentage Composition	Weight in Gramme
Silica sand	15%	75g
Feldspar	10%	70g
Calcium Oxide	8%	40g
Zirconium Oxide	5%	25g
Sodium Oxide	44%	220g
Cullet	14%	70g
Cobalt Oxide	4%	10g
	100%	500g

Table 6
Composition B3

Oxides	Percentage Composition	Weight in Gramme
Silica sand	20%	100g
Feldspar	9%	70g
Calcium Oxide	8%	40g
Zirconium Oxide	5%	25g
Sodium Oxide	40%	220g
Cullet	14%	70g
Cobalt	4%	10g
	100%	500g

Table 7

Composition A4

Oxides	Percentage Composition	Weight in Gramme
Silica sand	15%	75g
Feldspar	10%	70g
Calcium Oxide	8%	40g
Zirconium Oxide	5%	25g
Sodium Oxide	44%	220g
Cullet	14%	70g
Cobalt	4%	10g
	100%	500g

Table 8

Composition B4

Oxides	Percentage Composition	Weight in Gramme
Silica sand	20%	100g
Feldspar	9%	70g
Calcium Oxide	8%	40g
Zirconium Oxide	5%	25g
Sodium Oxide	40%	220g
Cullet	14%	70g
Cobalt	4%	10g
	100%	500g

Table 9

Composition A5

Oxides	Percentage Composition	Weight in Gramme
Silica sand	15%	75g
Feldspar	10%	70g
Calcium Oxide	8%	40g
Zirconium Oxide	5%	25g
Sodium Oxide	44%	220g
Cullet	14%	70g
Cobalt	4%	10g
	100%	500g

Table 10

Composition B5

Oxides	Percentage Composition	Weight in Gramme
Silica sand	20%	100g
Feldspar	9%	70g
Calcium Oxide	8%	40g
Zirconium Oxide	5%	25g
Sodium Oxide	40%	220g
Cullet	14%	70g
Cobalt	4%	10g
	100%	500g

The various materials were ground, weighed in the various proportions and mix in various crucibles, theses were then fired to a temperture of 1200^{o}C in a muffle kiln.


Plate 1: The crucibles were placed in the mufffle kiln for firing

Plate 2: the process of firing the samples

Plate 3: Fritting of the melt

Results of frit

Figure A1, A2, A3, A4 and A5 represent composition A with different metallic oxides. The result showed that the composition required a melting temperature of $1150^{o}C$ to melt than sample B.

FIGURE A1: Iron oxide

FIGUREA2:Chromium Oxide

FIGUREA3: Manganese oxide

FIGURE A4: Copper Oxide

FIGURE A5: Torques Cobalt Oxide

Figure B1, B2, B3, B4 and B5 represent composition B with various metallic oxide. The compositions required a higher temperature to melt than composition A, the required melting temperature was 1250..

FIGURE B1: Iron Oxide

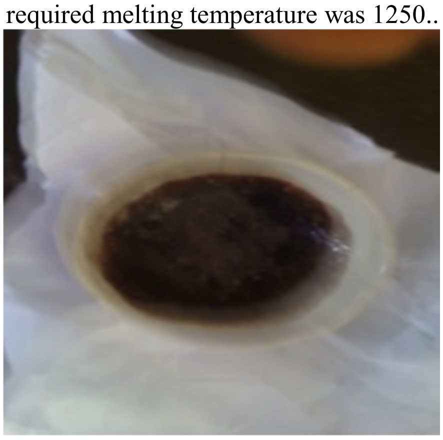

FIGURE B2: Iron Oxide


FIGURE B3: Manganese oxide


FIGURE B4: Copper oxide


FIGURE B5: Copper oxide

The various samples were later pulverized to obtain the various enamel stain.

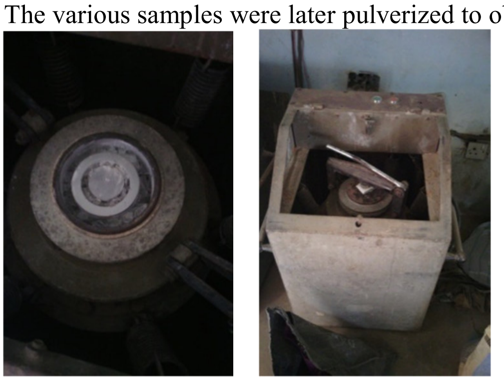
Plate4: Pulveriser

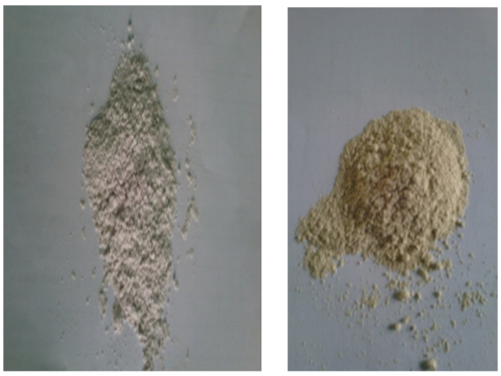
Plate 5: Pulverised frit

Testing of the enamel stain

Mixing agent: The mixing agent allows the powder material to flow so that it can stick to the body of the ware. It also allows the powdery enamel to pass through the mesh used.

Reheating: To make the enamel permanent on the glass surface, there is need to reheat the enamel in the kiln to a certain temperature. This involved placing the decorated item in the kiln and reheating to a temperature of 680^{o}C.

Plate6: The kiln and the test samples

Plate7: The result of some of the test piece.

The various results gotten from the experiment was used to print on a glass and ceramic cup using a mesh of size 100.. A print out logo was designed on a com puter system and transferred to the mesh using the required transfer technique.

DESIGN OF A LOGO TO PRINT ON A CUP USING THE ENAMEL

The various stages involved in the design of the logo on the cup are:-

Design of the logo on the computer: The logo was designed on the computer system and reduced to the size of 2cm by 2cm.

Expose of the design on the mesh: The design from the computer system was transferred to a fine mesh.

Plate8: The fine mesh

Printing on the cups: The produced enamel was placed on the mesh and printed on the ceramic and cups.

DISCUSSION
From samples A1, A2, A3, A4, A5, the result showed that the enamel required a lower temperature to melt than sample B. The reheating melting temperature of the enamel was 680^{o}C compared to that of B1,B2, B3, B4 and B5 which was 790^{o}C. The colours of composition A came out on the wares brighllaintly than that of composition B which is matt in colour.. The sagging of the glass panel was as a result of the reheating temperature of sample B being too high in an attempt to fuse the enamel unto the glass surface.

CONCLUSION
The use of silica from Igbokoda for the production of enamel was discovered to make the production of enamel cheaper in term of procurement of raw material and the fuel cost compared to some other methods of enamel production. It can be inferred from the experiment that the silica can be used for commercial production of enamel of a lower melting temperature with good resistance to acidic and basic attack.

RECOMMENDATION
I hereby recommend the use of Igbokoda silica for the production of enamel stain in Nigeria.

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