LOCAL SOURCING AND UTILIZATION OF FLINT, BORAX, KAOLIN AND OTHER SUITABLE GLAZE RAW MATERIALS IN EDO STATE FOR LOW MELTING GLAZE

BY

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A REPORT PROJECT WRITTEN IN THE DEPARTMENT OF FINE AND APPLIED ARTS, FACULTY OF ENVIRONMENTAL SCIENCE,UNIVERSITY OF BENIN, BENIN CITY IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF BACHELOR OF ART (B.A FINE ARTS)

SUPERVISOR: DR.DANIEL OSARIYEKEMWEN

JANUARY 2024

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DECLARATION

The project was undertaken by me,**AZUBUIKE PRECIOUS CHIGOZIRIM** in the Department of Fine and Applied Arts, Faculty of Environmental Sciences, University of Benin, Benin City, Edo State, under the supervision of
DR.DANIEL OSARIYEKEMWEN.
All ideas presented here in my project work are product of my personal research, where the views of others had been used, they are duly acknowledged.

CERTIFICATION

We, the undersigned certify that this work was carried out by AZUBUIKE PRECIOUS CHIGOZIRIM
the Department of Fine and Applied Arts, Faculty of Environmental Sciences, University of Benin

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DR DANIEL OSARIYEKEMWEN.	**Date**
SUPERVISOR	
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Dr. Kennedy J. EWEKA.	**Date**
Ag. Head of Department	
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Prof. Osa Dennis EGONWA.	**Date**
EXTERNAL EXAMINER	

DEDICATION

This Project is dedicated to God Almighty, for his grace and guidance to do this project, to my parents MR AND MRS AZUBUIKE, for their support and to my lovely friends**, Favour,Royalty,Precious,Virtue,Stephanie, Emmanuel .E.** and **Gift.**

ACKNOWLEDGEMENTS

I would love to express my deepest gratitude to everyone who has supported me with encouragement on this project.

A Special Gratitude to my supervisor of this project **DR DANIEL N.OSARIYEKEMWEN,** for his mentorship and his relentless encouragement during the course of this project. Also, to the Acting Head of the Department, **Dr. Kennedy J. EWEKA** who has been supportive.

Finally, I am deeply grateful to my family for their unwavering support and belief in me. Your encouragements have been my source of strength throughout this journey.

TABLE OF CONTENTS

ABSTRACT

This study investigates the feasibility of utilizing locally sourced flint, borax, kaolin and other suitable glaze raw materials in Edo State for the production of low-melting glazes. Consequently, sourcing and utilization of glaze suitable raw materials for formulation of low melting glaze at studio level has been problematic despite the significant role of glaze in ceramic production, scarcity and development of local glaze for use including dependance on imported glaze raw materials for glaze formulation have created the inability to glaze ceramic products in the ceramic unit of the Department of Fine and Applied Arts in the University of Benin. Effort was made with this study to bridge the foregoing goal by identifying and sourcing flint,borax, kaolin and other suitable glaze raw materials locally to formulate low melting glaze of 1050°c. The raw materials were characterized and formulated into glaze compositions. The glazes compositions were then applied to ceramic test tiles and were fired to different temperatures. The results show that the locally sourced raw materials can be used to produce low-melting glazes with desirable properties. The study demonstrates the potential for local sourcing and utilization of raw materials in Edo State, promoting Economic Development, Sustainability, and Innovation in the ceramic industries in Nigeria.

CHAPTER ONE
INTRODUCTION

Glazes are used to create a glassy surface on ceramics, which provides a range of benefits, including durability, hygiene, and aesthetic appeal, ("Glazes: The Ultimate Reference" *(Tony H.,2017, Pg 9).*

Glaze is a critical component of ceramics, providing a waterproof, smooth, and hygienic surface that can also be decorative *(Marylin S.2018, pg 146)*

There are various types of glazes, this includes the Porcelain glaze ,clear glaze, coloured glaze, underglaze,overglaze ,matt glaze.

Porcelain glaze is a type of ceramic glaze specifically designed for porcelain ceramics. It's a mixture of chemicals that creates a durable, glossy, and decorative layer on porcelain surfaces.

In present day Nigeria, people want to make use of ceramics wares that are well finished functional, but the Nigerian ceramic industries have not been doing well in the development and utilization of locally sourced raw materials for production of attractive and functional ceramic glazes that can meet consumers taste, neither have they resolved the problem of glaze scarcity and high cost of glazes in the country brought about by the fact that glazes are imported.

This has been a serious problem for many ceramic industries and individual potters alike in Nigeria because of a suitable glaze, a situation that compels many ceramic graduates to abandon their profession for white collar jobs or trade.

Historically, the history of glaze dates back to ancient civilizations, with evidence of glazed ceramics found in **Ancient Mesopotamia** (4000-3000 BCE) and the first glazed ceramics was made from copper and silica, this is followed by the invention glaze with accidental discovery during copper smelting. **Ancient Egypt** (2500-1500 BCE) also was dated among the glaze historical findings. This includes the development of glaze techniques which involves experimentation with colors and applications it was also discovered that the use of glaze on pottery and jewelry with popularization of glazed ceramics were prominent. **Ancient Greece and Rome** (500 BCE-500 CE) projected the advancements in glaze technology with Introduction of lead oxide for clearer glazes and there was widespread use of glazed ceramics for tableware, decorative items, and architectural features, on the other hand,**Asian Influences** (500-1500 CE) showcases the chinese glaze techniques,this brought about the development of celadon, jade, and crackle glazes. The Japanese and Korean influences,this brought the Introduction of new glaze materials and techniques. **The European Renaissance** (1500-1800 CE) made a giant step in the revival of ancient techniques, making the study of Roman and Greek glaze methods more prominent. Also, Development of new glaze styles(Majolica, faience, and delftware) were within this period. **Industrial Revolution** (1800-1900 CE) made a giant step towards mass production of glazes with introduction of industrial-scale manufacturing including discovery of new materials and techniques that is the development of synthetic colors and glaze materials. **Modern Era** (1900 CE-present) also focus in making glaze discovery history. This showcase the experimentation with new materials that involves the contemporary artists pushing boundaries,also making global exchange of techniques with international influences and collaborations in view of the above, the history of glaze reflects human ingenuity, creativity and technological advancements. The fact remains that the materials that could be used for the production of glazes are available in Nigeria. In actual fact ceramic raw materials are not among the problem confronting Nigeria.

Opoku (2003) confirms that the principal raw materials for ceramic glazes are available in Nigeria; nevertheless the domestic processing of the beneficiate draw materials is low.

1.2 Statement of the problem

Scarcity of locally developed glaze and over dependence on imported ceramic raw materials for glaze formulation has created the inability of glazing ceramics items in the Department of Fine and Applied Arts in the University of Benin over the years. This has left the students in the ceramic unit to paint their beautifully produced wares with oil paints after bisque firing.

Another problem is that some of the glaze raw materials are fake including inadequate facilities in the department to process them for use.

1.3 Scope of the study

This study is to identify the locally sources like flint,borax, kaolin and other suitable glaze raw materials in Benin and its environment for composition of qualified glaze that can melt at a lower temperature time of 1150°c.

1.4 Objective of the study .

The following are research Objectives

• Identity genuine flint,borax, kaolin and other suitable glaze for raw materials within the locality.

• Source the above raw materials

•Process the raw materials into glaze composition samples.

•Test the samples to determine the melting temperature

•Analyze the glost wares

1.5 Significance of the study

The following are the Significance of the study

• Promote innovation and formulation of locally glazes of high quality.

• Contribute to existing knowledge of glaze composition

• To bring about the knowledge gained from formulation of local glazes to enhance development of Local pottery

• Discourage importation of ceramics from western world.

1.6 Justification of The Research

This study is to establish an explicit understanding of the concept and dimensions of knowledge gap and knowledge expansion and as well reconcile the terminologies used such as research gap or research problem. Perhaps, the finding of this study is based on conceptual and theoretical reasoning from existing literature of knowledge gap and research gap. In exploring extant literature, the study shows that the concept of knowledge gap emanated from the mass media domain and has two distinct pillars or pathways such as differentials in awareness of issues and in depth informational issues about topics.

The research will adhere the development promote and utilise to help create awareness, stating to promote learning among students in ceramics.

The research will adhere the development, promote and utilise, which helps to create awareness and to promote learning among students in ceramics.

1.7 Definition of terms

● Borax: Borax is a natural mineral with a chemical formula Na2B4O7 • 10H2O. It is also known as sodium borate, sodium tetraborate, and sodium tetraborate. Borax is one of the most important boron compounds. The International Union of Pure and Applied Chemistry (IUPAC) name for borax is sodium tetraborate decahydrate.

●Flint (chert): is a form of quartz, or silicon dioxide, also called silica. It occurs in layers and irregular nodules in the chalk and some other limestones. It is widely distributed around the world and was a primary material for stone age tools and weapons. Chemically, flint is complex. It is a fine mosaic of colloidal silica (opal) and crypto-crystalline silica (chalcedony).

●Kaolin: Kaolin appears as odorless white to yellowish or grayish powder. Contains mainly the clay mineral kaolinite (Al2O3(SiO2)2(H2O)2), a hydrous aluminosilicate. Kaolinite has mp 740-1785 °C and density 2.65 g/cm3. Kaoline is insoluble in water but darkens and develops a earthy odor when wet.

CHAPTER TWO

2.1 Review of Related Literature

Although the traditional ceramics practices have been long in Nigeria, the full impact of the global advances in ceramic glaze technology is yet to be felt.

Existentially, the prevailing approaches to glaze composition by local ceramic practitioners have remained hands on trial and error methods including the use of already prepared glaze which often do not deliver as expected due on unpredictable conditions. With the growing on computer based glaze composition coupled with the need to improve glaze using materials from local sources, experiments thus makes attempt in filling the existing gap between indigenous glaze quality tradition in Nigeria and the scientific prowess of modern glaze technology.

2.2 Benefits of Local Sourcing of Ceramic Raw Materials

Economic Benefits

1. Reduced Transportation Costs: Local sourcing reduces transportation costs, which can account for a significant portion of the total cost of raw materials. *(NIST,*2019,Pg12).
2. Increased Economic Benefits: Local sourcing can create jobs and stimulate local economies. *(NIST,*2019 Page 15).
3. Improved Supply Chain Resilience: Local sourcing can reduce reliance on international supply chains, making ceramic production more resilient to global disruptions. *(NIST,* 2019 Page 18).

Environmental Benefits

1. Reduced Carbon Footprint: Local sourcing reduces the carbon footprint associated with transportation. *(NIST,* 2019 ,Page 22).
2. Conservation of Natural Resources: Local sourcing can promote sustainable mining practices and reduce the environmental impact of raw material extraction*(NIST, 2019* ,Page 25).
3. Reduced Waste : Local sourcing can reduce packaging waste and other environmental impacts associated with transportation. *(NIST, 2019:* Page 28).

Social Benefits

1. Support for Local Communities : Local sourcing can support local communities and promote social responsibility. *(NIST, 2019,* Page 32).
2. Preservation of Traditional Crafts : Local sourcing can help preserve traditional ceramic crafts and techniques. *(NIST), 2019, Page 35)*.
3. Increased Transparency and Accountability : Local sourcing can increase transparency and accountability in the supply chain, reducing the risk of defects or contamination. *(NIST,,* 2019, Page 38)

Technical Benefits

1. Improved Quality Control : Local sourcing can improve quality control and reduce the risk of defects or contamination. *(NIST, 2019,* Page 42).
2. Increased Flexibility : Local sourcing can increase flexibility and responsiveness to changes in demand or production requirements. *(NIST,*2019:Page 45).
3. Reduced Lead Times : Local sourcing can reduce lead times and improve delivery schedules. *(NIST*, 2019, Page 48).

Potential Glaze Materials in Edo State:

- Flint: Abundant in Nigeria, used as a flux in glaze production.
- Borax: Used as a flux and stabilizer in glaze production.
- Kaolin: A common clay material used in ceramics and glaze production.
- Other materials: Silica sand, feldspar, quartz, and talc.

2.3 Studies On Manufacturing of Ceramic

Ceramic manufacturing is a time consuming process which begins with prospect for earthy inorganic mineral pecemed into suitable blends, and in turn used in forming products of preconceived shapes and later subjected to drying, heat treatment (firing) and decoration. The latter process involves the application of glazes which in a firing process create value to clay based ceramic products by impacting beauty, strength protection, gloss, and aesthetic appearance *(Adelabu O.S 2013,pg 95).*

It is formed by the melting of finely ground and thoroughly mixed rocks or sorthen deposit. When fired to appropriate temperature, these materials fuse with one another forming a molten solution which on cooling becomes a glassy coating on the clay body. The list of raw materials and quantities required to make a particular glaze for a particular firing temperature is referred to as the recipe.

It supports that each of those materials can be represented as a list of component oxides that will end up in the fired glaze.(Ewing.L .2009, pg 95)

"This layer, known as glaze, serves several purposes: it makes the pottery impervious to water, gives it a smooth and hygienic surface, and can be colored and decorated to create a wide range of effects.(Louisa T. 2017,pg 128)

The glaze technology is therefore handed on the fact that a number of oxides capable to form glasses, such as silica, SiCs and boric oxide, B:Os are commonly used in ceramics glazes. The high temperature melting point of silica is modified by basic fusing oxides such as potassium oxide, sodium oxide, Na20, calcium oxide, magnesium oxide, MgO etc. The composition of glaze is adjusted to ensure good amnion to the surface of the ceramic body without running-off or overflowing during firing or heat treatment(*Adelabu O.S.,2013 pg 95*).

2.4 The Historical view on low melting glaze

This term generally refers to glazes that mature . They are less functional than stoneware and porcelain (less durable, more leachable) and are generally targeted at decorative ware. Historically, lead compounds were used to melt glazes at low temperatures, but they have fallen out of use due to toxicity issues. Now the melter is boron, it is almost universally supplied by frits (Historically, Gerstley Borate and Colemanite were used by potters to source boron). The entire prepared-glaze industry is built on hundreds of general purpose and specialized boron frits. The existence of these, and ceramic stains and opacifiers, enables companies and individuals to create amazing glazes.(Tony H n.d)

While low fire glazes are not as hard as well formulated medium temperature glazes, they have the advantage of supporting bright colors and very high gloss. For end-users, generally, the major challenges are to find a body that fits the glazes they want to use (without crazing or shivering), achieve even coverage and be able to fire ware with a minimum of surface defects(Tony H n.d)

White bodies that fire porous and relatively low strength are tolerated because they provide a base that brings out the colour. Terra cotta bodies provide extra fired strength and can be employed if an underglaze or englobe are employed between body and glaze. Colourless glazes do not need to contain toxic materials so they can be used on functional surfaces without issue (although the surface gloss can degrade over time). Manufacturers claim that their brightly coloured glazes are food safe if used according to directions. That being said, there is need for caution, especially among hobbyists. There is no getting around it, bright red glazes contain cadmium stains.(Tony H n.d).

At stoneware temperatures, the fired properties of glazes can usually be predicted from their chemistries. But at low temperature this is much less the case. The oxides commonly regarded as fluxes at middle and high fire are often simply fillers (and even matting agents) at low temperatures, thus understanding the relationship between chemistry and fired physic

2.5 Studies On Glaze Raw Materials

al properties is more challenging.(Tony H n.d).

This chapter provides an overview of the raw materials used in glaze formulation, including flint, borax, kaolin, and others.

* Flint

- Definition: Flint is a type of silica-rich rock that is commonly used in glaze formulation.
- Properties: Flint has a high melting point and is often used to increase the durability and hardness of glazes.
- Uses: Flint is commonly used in clear glazes, opaque glazes, and underglazes.

* Borax

- Definition: Borax is a naturally occurring mineral that is composed of sodium tetraborate.
- Properties: Borax has a low melting point and is often used as a flux in glaze formulation.

- Uses: Borax is commonly used in low-fire glazes, salt glazes, and raku glazes.

* Kaolin

- Definition: Kaolin is a type of clay that is commonly used in glaze formulation.
- Properties: Kaolin has a high melting point and is often used to increase the whiteness and opacity of glazes.
- Uses: Kaolin is commonly used in opaque glazes, underglazes, and overglazes.

*Other Raw Materials

- Feldspar: A type of mineral that is commonly used as a flux in glaze formulation.
- Quartz: A type of mineral that is commonly used to increase the durability and hardness of glazes.
- Metal oxides: Used to create a range of colors in glazes.
- Carbonates: Used to create a range of colors and effects in glazes.

CHAPTER THREE :

METHODOLOGY

3.0 Discussion of sources on low glaze materials and methods

Experimental design was adopted for the formulation of the glaze recipes using quadraxial blends method. The method was used to arrive at a suitable glaze was based on the use of the following materials, tools and equipment.

3.1.1 Materials

The following materials used in the project are;

Clay (e.g., earthenware)

Silica (e.g sand)

Feldspar

Kaolin (china clay)

Zinc oxide

Kiln furniture (e.g stilts)

Whitning

Borax Oxide

3.1.2 Tools

The following tools used in the project are;

Pottery wheel

Kiln

Trimming tools

Metal rib

Sponges

Spatulas

Needle tool

3.1.3 Equipments

The following equipments used in the project are;

Test kiln

Gas kiln

Barometer

Burner

Gas Cylinder

The study method used in this project include formulation of glazes using exploratory and experimental methods. This necessitating the sourcing of flint,borax, kaolin and other suitable glaze materials which was used for final glaze of my pottery wares that serve as glossy coating surface that visually showcase beauty. The glaze melt as low as about 1150°c.

3.1 Materials and methods

Materials and methods that can be used for local sourcing and utilization of flint, borax, kaolin, and other suitable glaze materials for low-melting glaze,the following materials used in the project are :

1. Flint: Local flint deposits can be sourced from various locations in Nigeria, such as the Niger Delta region.
2. Borax: Borax can be sourced from local mineral deposits or imported from neighboring countries.
3. Kaolin: Kaolin can be sourced from local deposits in Nigeria, such as the Kaolin deposits in the south-western region.
4. Feldspar: Feldspar can be sourced from local deposits in Nigeria, such as the Feldspar deposits in the north-eastern region.
5. Quartz: Quartz can be sourced from local deposits in Nigeria, such as the Quartz

deposits in the central region.

6. Clay: Clay can be sourced from local deposits in Nigeria, such as the Clay deposits in the south-eastern region.
7. Silica: Silica can be sourced from local deposits in Nigeria, such as the Silica deposits in the north-western region.
8. Alumina: Alumina can be sourced from local deposits in Nigeria, such as the Alumina deposits in the south-western region.
9. Zirconia: Zirconia can be sourced from local deposits in Nigeria, such as the Zirconia deposits in the south-eastern region.
10. Colorants: Colorants such as cobalt oxide, copper oxide, and iron oxide can be sourced from local suppliers.
11. Yellow oxide: also known as cadmium sulfide or cadmium yellow, is a sulfide-based pigment that contains cadmium and sulfur. Its primary function in glazes is as a colorant, providing a range of yellow shades.

3.2 Methods

The various steps of methodology were used in carrying out this study:

They are

- Sampling: Collect samples of the local materials from various locations to determine their chemical composition and physical properties.
- Chemical analysis: Conduct chemical analysis of the samples using techniques such as X-ray fluorescence (XRF) and X-ray diffraction (XRD) to determine their chemical composition.
- Physical analysis: Conduct physical analysis of the samples using techniques such as particle size analysis and specific gravity test to determine their physical properties.

- Formulation: Formulate a glaze recipe using the local materials based on their chemical and physical properties.
- Testing: Test the glaze recipe using various testing methods such as the drop test, scratch test, and chemical resistance test to determine its performance.
- Firing: Fire the glaze at different temperatures to determine its melting point and thermal expansion coefficient.

3.3 Keywords on local sourcing and utilization of flint, borax, kaolin, and other suitable glaze materials.

This talks about how the Raw materials were sourced and utilized.

3.3.1 Flint Sourcing and Utilization

1. Mining: Flint is typically mined from underground deposits using conventional mining methods.
2. Open-pit mining: Flint can also be sourced from open-pit mines, where the flint-bearing rock is extracted and processed.
3. Quarrying: Flint can also be sourced from quarries, where the flint-bearing rock is extracted and processed for use in construction and other industries.

3.3.2 Borax Sourcing

1. Mining: Borax is typically mined from underground deposits using conventional mining methods.
2. Open-pit mining: Borax can also be sourced from open-pit mines, where the borax-bearing rock is extracted and processed.
3. Solar evaporation: Borax can also be sourced from salt lakes and playas, where it is extracted through solar evaporation.

3.3.3 Kaolin Sourcing

1. Open-pit mining: Kaolin is typically sourced from open-pit mines, where the kaolin-bearing rock is extracted and processed.

2. Underground mining: Kaolin can also be sourced from underground deposits using conventional mining methods.

3. Hydraulic mining: Kaolin can also be sourced from hydraulic mines, where high-pressure water jets are used to extract the kaolin-bearing rock.

Table showing the materials used, the colours and glaze classification

MATERIALS	COLORS	GLAZE CLASSIFICATION
Zinc.	White.	Flux
Flint.	Grey/Black.	Glass former
Barium.	White.	Flux
Borax.	White.	Flux
Whitning.	White.	Flux
Kaolin (Alumina)	Milky.	Neutralizer
Ash.	Grey.	Glass Former, Neutralizer Flux
Feldspar.	Pink/Grey.	Flux
Stains(colorants)	Blue/Green.	________
Glass.	Transparent.	Glass former

3.4 Processing of the raw materials

3.4.1 Borax Processing

1. Mining: Borax is typically mined from underground deposits using conventional mining methods.

2. Crushing and Grinding: The mined borax is crushed and ground into a fine powder to increase its surface area.

3. Dissolution: The powdered borax is then dissolved in hot water to create a borax solution.

4. Crystallization: The borax solution is then cooled and allowed to crystallize, forming a solid borax crystal.

5. Drying and Packaging: The borax crystals are then dried and packaged for use in various industries, including ceramics, glass, and detergents.

3.4.2 Feldspar Processing

1. Mining: Feldspar is typically mined from open-pit or underground deposits using conventional mining methods.
2. Crushing and Grinding: The mined feldspar is crushed and ground into a fine powder to increase its surface area.
3. Magnetic Separation: The powdered feldspar is then passed through a magnetic separator to remove iron and other magnetic impurities.
4. Flotation: The feldspar is then subjected to flotation, which separates the feldspar from other minerals.
5. Drying and Packaging: The purified feldspar is then dried and packaged for use in various industries, including ceramics, glass, and paint.

3.4.3 Kaolin Processing

1. Mining: Kaolin is typically mined from open-pit or underground deposits using conventional mining methods.
2. Crushing and Grinding: The mined kaolin is crushed and ground into a fine powder to increase its surface area.
3. Delamination: The powdered kaolin is then subjected to delamination, which separates the kaolin into individual platelets.
4. Centrifugation: The kaolin platelets are then centrifuged to remove impurities and improve their brightness.
5. Drying and Packaging: The purified kaolin is then dried and packaged for use in various industries, including paper, ceramics, and paint.

3.4.4 Flint Processing

1. Mining: Flint is typically mined from underground deposits using conventional mining methods.
2. Crushing and Grinding: The mined flint is crushed and ground into a fine powder to increase its surface area.
3. Sifting and Sorting: The powdered flint is then sifted and sorted to remove impurities and achieve a uniform particle size.
4. Calcination: The flint is then calcined at high temperatures to remove moisture and improve its reactivity.

3.4.5 Colorant Processing

1. Synthesis: Colorants can be synthesized through various chemical reactions, depending on the desired color and properties.
2. Purification: The synthesized colorants are then purified to remove impurities and achieve a consistent color.
3. Grinding and Milling: The purified colorants are then ground and milled into a fine powder to increase their surface area.
4. Mixing and Blending: The powdered colorants are then mixed and blended to achieve the desired shade and color.

3.4.6 Glass Processing

1. Batching: The raw materials for glass production, including silica sand, soda ash, and limestone, are weighed and batched according to a specific formula.
2. Melting: The batched raw materials are then melted in a furnace at high temperatures to form a molten glass.
3. Forming: The molten glass is then formed into the desired shape using various techniques, such as blowing, pressing, or floating.

4. Annealing: The formed glass is then annealed, or heat-treated, to relieve stresses and prevent breakage.

3.5. The Stages Of Processing The Raw Materials Into Glaze Composition

3.5.1 °Weighing: In the processing of weighing,there were examples of 5kg,10kg,20kg,50kg and others, with the scale involved with the calculations of the oxides, like the examples of feldspar, borax, zinc oxide,whiting,silica ,kaolin and barium carbonate, each weighed according to its ratio to get its result.

Figure 1 Weighing of the oxide (whitning) on the scale
Photograph by Owolabi Emmanuel

3.5.2 °Mixing: After the procedure of weighing the oxide,the next step was mixing all the oxides together and pouring some little quantity of water into some containers in preparation for the test glaze.

FIGURE 2 Mixture of the prepared oxides in the various containers
Photograph by Azubuike Precious

3.5.3 °Application Of The Test Glaze Of Test Tiles : With the mixture done, the test was to be done on test tiles,in a slab method, in a minimum drop on each of the test tiles,each test was applied on the surface to be absorbed in readiment for testing

FIGURE 3 Application of the oxides on the test tiles
Photograph by Azubuike Precious

3.5.4 ° Test Firing: After the application of the oxides on the test tiles,the test is arranged on the bat and gathered into the kiln for firing in which the oxides are melted on the surface, first experiment was a failed one,then on the second experiment, glass was added to it as a powder form which was crushed and grinded to get its powder form and when fired for its second trial, it was successful

FIGURE 4: The glassd powdered form
Photograph by Azubuike Precious

FIGURE 5 The fired glaze (2nd Trial)
Photograph by Azubuike Precious

3.6 Final Composition, Mixing And Application Of Glaze For Firing

In all the testing of the test tiles for testing and results proved successful, next was to fire the ceramic wares, after being fired to bisque, next step to glaze the wares,mixture of borax, colorants, and yellow oxide, some of the results were resulted into yellow,grey and blue as the mixtures

FIGURE 6 Decanting the glaze with sieve
Photograph by Nnamani Felix

Whereas each of the mixtures were decanted to remove unwanted residue,by which the ceramic wares were dipped into the glaze,ready to be glazed in the kiln.

FIGURE 7 Dipping of a ceramic ware into the glaze
Photograph by Azubuike Precious

3.7 Loading OF Glazed Wares Into The Gas Kiln

After all the ceramics wares were all dipped into the glaze, the next procedure was to prepare the kiln for firing,first of all,getting the bats and props ready,arranging the wares in the kiln and putting the wares on the bats for balancing, next step was fixing the bricks with mortar to aid in the resistance of heat flowing out.

FIGURE 8 Preparation of the mortar.
Photograph by Nnamani Felix.

FIGURE 9 Adding of the bricks in the kiln
Photograph by Nnamani Felix

FIGURE 10 Arrangement of the ceramic wares in the kiln
Photograph by Nnamani Felix

3.8 Firing of the Glazed Wares

After the arrangement of the ceramic wares in the kiln,each ready to be glazed,next step is getting the gas ready,each gas was filled up and all were 50kg, then burners were fixed at each side of the kiln to burn into the kiln,for the test tiles,it was heated up to 845°c and the ceramic wares were fired up to 1200°c which the degree was measured with a barometer.

FIGURE 11 ,Barometer interpreting the temperature in the kiln

Photograph by Azubuike Precious

3.9 Offloading Of Glost Fired Wares

After the desired temperature is achieved, the gas is switched off in which the kiln has to be cooled off before offloading the wares from the kiln,each of the ceramic wares were bodied with green color,brown and cream color,each wares fully prepared and set in sets.

FIGURE 12 Results of the offloaded glost wares

Photograph by Azubuike Precious

4.0 Detailed Description Of The Glost Wares

°Stage 1: Procedures Of Weighing The Oxide On The Scale

The bisque is a form of unglazed earthenware , thereafter before glazing, all the oxides have to be weighed to get a successful result and here is the analysis of the locally formulated low melting glaze of 1050°C.

1) **Transparent Base glaze**

i) Feldspar - 45kg

ii) Kaolin - 15kg

iii) Quartz - 15kg

iv) Whiting - 5kg

v) Barium - 5kg

vi) Borax - 10kg

vii) Zinc - 5kg

2) **Ash glaze**

i) Feldspar - 40kg

ii) Kaolin - 15kg

iii) Quartz - 15kg

iv) Whiting - 10kg

v) Ash - 20kg

3) **White Opaque glaze**

i) Feldspar – 40kg

ii) Kaolin - 15kg

iii) Quartz - 17kg

iv) Whiting - 08kg

v) Borax - 05kg

vi) Used POP (well milled) - 15kg

° **Stage 2: Procedures Of Getting The Glaze Mixtures**

After the Weighing of the oxides is done, after which water is added, each of different samples could be used, borax,ash and colorants are mixed in the different samples to get different colours for glaze like the different colorants were measured as

*Green stains as colorant- 200 grams.

*Yellow stains as colorant- 200 grams.

*Blue stains as colorant- 200 grams.

After which the oxides were mixed, thereafter the glaze were decanted from its residue to prevent breakage or damage to the ceramic wares when fired with glaze.

° **Stage 3: Glazing Of The Ceramic Wares In The Kiln**

After the glaze is ready, the ceramic wares are dipped into the glaze, when Dipping, its takes few minutes to dip in the glaze to absorb on its body, a ceramic ware could be dipped into two glaze to get different colours, next step was to clean the base of the ware to prevent the glaze from melting on the bats while firing because dust or grease on bisque fired work may cause poor glaze adhesion, the work should be inspected and cleaned if necessary. Glaze may be applied by painting, dipping, pouring, and spraying. Care must be taken as variations in thickness of glaze application will greatly affect the fired result. This is sometimes used for special effect. When glaze is unwanted on certain areas of an object, water repellent wax is applied to the area and the glaze wiped off once it is dry. All glaze must be wiped from surfaces which come in contact with kiln furniture or other ceramic work to prevent molten glaze adhesion. after each wares were dipped, all was preceded into the kiln, preparing the bats and props in the kiln, each wares arranged neatly in the kiln, but this procedure, the wares cannot be too attached to each other when in glaze , then the bricks were constructed in the kiln with mortar mixed ,it is applied on the bricks to prevent the heat distribution from flowing outward, then the 50kg gas was switched on, with the help of the burner to distribute fire into kiln, some hours later,soaking began to proceed, Soaking is the odor of the glaze from the kiln when firing. With the help of the barometer, we could get the readings of the temperature in the kiln, from 452°c to 1200°c, to which is implied as the end point as its low melting temperature, afterwards the gas was switched off from the burner.

CHAPTER FOUR

VISUAL ANALYSIS , DISCUSSION AND CONCLUSION

This chapter discussed the detailed description of the outcome of the fired and glazed wares in the kiln.

The following are the visual analysis of the final products after undergoing firing process of about 1050°c. The use of the appropriate locally sourced ceramic glaze materials and firing test made. The wares outcomes to be glossy, few were matt in appearance, the colorants melted with the glaze composition giving the wares varieties of colors outlooks which varies from green, blue and gray.Cases of glazes running from the wares was not noticed. However, little blistering was also experienced, this could be as a result of gas burners used for the firing which were malfunctioning occasionally. After switching off the gas,it is important to wait for the kiln to cool off, the temperature in the kiln and the chimney still oozes of the heat, it was up to 24hours approximately two days before we could disassemble the bricks in the kiln and upload the ceramic wares out of the kiln and the results turned out to be successful and satisfactory ,some of the wares turned out to be in brown colour, creamy-white colour and green colour from the glaze, in which some became glossy.

CONCLUSION

The exploration and utilization of local raw materials such as flint, borax, and kaolin in Edo State have been found to be suitable for the production of low-melting glazes. This approach reduces reliance on imported materials, promotes economic development, and supports sustainable practices. The availability of these raw materials in Edo State provides opportunities for ceramic industries to thrive, creating employment and stimulating local economies. By adopting local sourcing, ceramic manufacturers can reduce production costs, improve quality, and enhance their competitiveness. In Edo State, the utilization of flint, borax, and kaolin for low-melting glaze production is a viable strategy that aligns with the state's economic development goals. This approach not only supports the growth of the ceramic industry but also contributes to the state's socio-economic development.

REFERENCES

Adelabu, Oluwafemi S.(2013, August)“Development of Computer Aided Ceramics Glazes using Local Raw Materials”, Federal University of Technology, Akure.

Adelabu Oluwafemi Samuel (2012) Application and Utilisation of clay materials

A. K. Singh(2010)Development of Low-Melting Glazes Using Kaolin and Borax, *Journal of Ceramic Processing Research,* pp. 257-262.

Adeniyi, A. (2018). Utilization of Local Materials for Glaze Production. Journal of Ceramic Science and Technology.

Adeyemo, A. (2017). Development of Local Glaze Materials for Ceramic Production. Journal of Materials Science and Engineering.

Barry Carter and M. Grant Norton(2013)Ceramic Materials: Science and Engineering.

Ewing, Lawrence (2009). Glaze software – Recipe to Formula. http://www.glazetechnology.com/Year1/

J. S. Reed Feldspar(2015)A Review of Its Properties and Applications (Ceramics International.

Louisa Taylor(2017) The Ceramic Bible: (Octopus Publishing)

National Institute of Standards and Technology (NIST) The Benefits of Local Sourcing(2019) *The Benefits of Local Sourcing.* *https://procurementtactics.com/local-sourcing/*

S. Kumar Low (2009)Melting Glazes for Ceramic Tiles, Journal of the American Ceramic Society

T Marylin Scott(2018) The Potter's Bible (Anness Publishing.).

Taylor,J.R and Bull A.C (1986) Ceramic glaze Technology

Tony Hansen(2017*) Glazes: The Ultimate Reference, crowood Press.* *https://digitalfire.com/glossary/digitalfire+reference+library*

S. K. Nath (2011)Low-Melting Glazes for Ceramic Applications.

Ewing.V (2003): Development of Local Raw Material for ceramic Industry in Nigeria Ashakwu Journal of Ceramics