

CHARACTERIZATION OF GRANITIC IGNEOUS ROCK FOR DEVELOPMENT OF FUNCTIONAL CERAMIC GLAZES

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ABSTRACT: Granitic Igneous rock is commonly found as granite dust on most quarry site, this form of igneous rock possess the same elemental composition with feldspathic and kaolinite minerals found in-situ, granitic igneous rock found along Klington Quarry Site was characterized using XRF to determine the percentage composition of the granitic Igneous Rock and XRD to understand the mineralogical phase distribution. The granite dust was mixed in proportion with feldspar and wood ash respectively to detect the best functional composition suitable for forming a ceramic glaze. The mixture was fired to a temperature of 1250°C with composition G4 exhibiting the most promising result.

KEYWORDS: granitic igneous rock, functional ceramic glazes.

1 INTRODUCTION

Granite is a product of forceful upheavals that usually compel silica-rich magma up toward the earth's outer layers, which cool slowly for thousands of years to form the large-grained crystalline rocks. Granite further undergoes chemical weathering to cause some feldspar and mica minerals present in granite rock to further decompose into clay minerals. Granite is noted for its use all over the world for construction and building of houses, it's often used by construction companies for aggregate reinforcement and coarse material. In addition to its application in building industry, granite is also found to be an important ceramic raw material which is found suitable for production of ceramic glazes.

The use of granite in the ceramic industry until now never attracted much attention despite its physical attributes that makes it a suitable material in a wide range of applications in ceramics. Studio experiments by Alkali (1995) shows that granite wastes are a cheap source of glaze flux and have the additional advantage of being nonsoluble. Torres, Fiernandes, Tulyaganov and Ferreira (2003) however observed that because of the presence of Al_2O_3 and SiO_2 in granite, it cannot be considered for low temperature flux. However, the fluxing action could be increased by the fineness of its particle size. Conrad (1980) further observed that granite rock because of its similarity in characteristics with feldspar could serve as alternative material to feldspar in the formulation of clay bodies and ceramic glazes.

In spite of the fact that granite industry in Nigeria generates a large amount of wastes in form of fine grain size powder which during rainy seasons transform into mud leading to some environmental damage, little attention is given to its maximum utilization for other industrial applications apart from its widespread use in the building industry. The use of granite wastes as alternative raw material in ceramics is quite a viable option that can contribute in not only diversifying the offer of raw materials but can save cost, provide alternative raw materials and new aesthetic advantage. Dijkema, Reuter and Verhoef (2000), stated that, nowadays, industries are searching for alternative raw materials that are less costly and recyclable so as to minimize waste as well as conserve the primary raw materials. The use of granite waste as alternative raw material in ceramic industry is yet to attract the attention of most researchers apart from its seldom use as a fluxing agent in the production of glazes. The chemical composition of granite which consists of SiO_2 , Al_2O_3 , F_2O_3 and CaO , makes it a suitable material for use in other applications in the ceramic industry apart from its present use as a glaze material.

Obstler (2010) informs that the list of glaze cores is long and disparate and then exemplifies some which includes feldspars, mica, granitic rocks, some clay, volcanic ash, wood ash, boron minerals, and the artificial manufactured frits. Glaze cores in this context refer to the general classification assigned to lists of primary glaze materials which possess the inequality to form an almost acceptable glaze surface at stoneware firing temperatures. In other words, the potentialities of the materials lie in their ability to provide glass forming, stabilizing, and fluxing oxides even as a single materials.

Since glaze contribute significantly to the finishing of the ceramic products, the exploration of local materials for glaze development is fast becoming essential in view of the cost of procuring imported glaze materials. The understanding of the available ceramic materials is seen as key maximizing their potentials for ceramic production. Efforts have been made by many ceramics in formulating of different types of glazes such as stoneware, ash and porcelain. These are high temperature glazes and have an adverse effect on final cost of production of our ceramic wares which might not make it to compete favourably with imported ceramics. It is observed that not much has been done on earthenware glaze, these are low temperature glazes that mature within the temperature range of 950°C – 1100°C and in other to encourage ceramics that have interest in pottery production the development and use of low temperature glaze should be encourages.

1.1 DEVELOPMENT OF CERAMICS AND GLAZES IN NIGERIA

Since the beginning of the 20th century, ceramics in Nigeria continued to evolve from its traditional origin to modern creative expressions (Ali, 2002). Significantly, the arrival of the Western culture and technology in the area of mechanization and high firing brought new approach to the Nigerian traditional pottery which was vastly void of glaze decoration. Fowowe (2003) states that the contemporary ceramics was first initiated by D. Robert at Ibadan in 1904 where he trained men with modern method of throwing on the potter’s wheel, glazing and kiln operation. The experiment failed due to tribal value system (gender occupation), improper planning and poor logistics after his departure in 1912. Fowowe (op cit) further explained that similar experiment was carried out by Micheal Cardew in 1950 and was successful. Oyeoku (2009) and Oyelola(1981) point that Cardew’s fieldwork led to the establishment of the Abuja Pottery Center in 1952 where he recruited trainees. This development led to the birth of the contemporary ceramics as a course in the few tertiary institutions that offered art programmes in the 1950s and early 1960s. The institutions have produced many talented young men and women in the art of contemporary pottery. Some corporate bodies and individuals have also established small and large scale ceramic industries and studios in different parts of the country producing glazed ceramic products for domestic consumption.

1.2 BASICS OF GLAZE COMPOSITION

Latorre (2009) portrays a glaze as a thin coating of glass that covers a ceramic object. The glass can be transparent, translucent, or opaque, dependent on the interaction of the materials that have gone into making that particular glass.

The main ingredient in glass is Silica, also known as silicon dioxide. Although silica alone can form a glass or glaze, it melts at much too high a temperature (1710°Celsius or more) for it to be feasible to make a glaze with this material alone. In order to make the silica melt at a lower temperature, one must add a melter, or flux to the silica. Silica and flux are all that’s required when making glass for glass objects such as blown glass vessels. Unfortunately, this is not all that’s required in order to make most pottery glazes. The combination of silica and flux makes for a very liquid, easily flowing glass that would end up predominantly on our kiln shelves rather than on our pots. One more ingredient is required in order to keep the glaze on the ceramic body during the firing cycle.

Alumina, an aluminum oxide molecule (Al₂O₃) is the ingredient which is referred to as a stiffener. This makes the molten glaze more viscous, like comparing water (silica and flux mixture) to molasses (silica, flux, and alumina mixture). Once again, the glass former forms the glass structure. The flux lowers the temperature at which the glass former melts, and the stabilizer increases the viscosity of the glass so that it does not run off the pot and pool on the kiln shelf. Each of these three things that make up the fired glaze is in the form of “oxides”.

Basic ingredients in a glaze



Fig 1: A simple graphical representation for glaze composition

The glass former oxide has the form of one atom of an element combined with two of oxygen (again, SiO₂). The flux has either the form of two atoms of an element combined with one atom of oxygen (generally stronger fluxes), or one atom of an

element combined with one atom of oxygen (generally weaker fluxes). The stabilizer has the form of two atoms of an element combined with 3 atoms of oxygen (again, Al_2O_3). In glaze chemistry, these three types of oxides are commonly referred to as RO or R_2O for the fluxes (with R used as a placeholder replacing the symbol for the element in the table), R_2O_3 for the stabilizer and RO_2 for the glass former. For those chemically inclined, the flux is also known as a “base”, the stabilizer as an “amphoteric”, and the glass former as an “acid” due to their chemical composition. Following is a table with some of the more common oxides found in a fired glaze.

2 MATERIAL PROCESSING

Crushing: The raw materials

Pulverization

Sieving

Ball Milling

2.1 GRANITIC IGNEOUS ROCK CHARACTERIZATION

The granitic igneous rock was collected from the Klington Quarry along Ise Road of Ekiti State Nigeria. Sample was milled to its finest particle using a Jar mill, and was later dried at 120°C for 10 hrs. XRF analysis was conducted to determine the percentage composition of metallic and non metallic oxides that makes up the Granitic Rock. The chemical analysis was conducted to find out the chemical composition of sample mineral so as to confirm their presence and values. The chemical composition of granite showed the dominance of alumina, silica and feldspar. Alumina serves as a stabilizer, silica acts as glass formers while feldspar represents the flux. These minerals were equally found in dominance both in kaolin and ball clay showing the viability of granitic igneous rock having a combined oxide composition of feldspar and kaolin. This definitely showed a little readjustment of body composition of granite dust will produce a viable glaze.

Table 1: XRF Analysis of Granitic Igneous Rock

Compo	Al	Si	S	K	Ca	V	Mn	Fe	Cu	Zn	Ba	Ti	Eu	Re
Conc unit	12.8%	58.4%	0.072%	11.3%	5.06%	1.22%	0.032%	4.52%	10.33%	0.026%	0.058%	0.35%	0.16%	0.09%

Source: Authors Field Work

2.2 MINERALOGICAL ANALYSIS

The powdered granitic igneous rock sample was also dried in an oven at 120°C for 10 hrs, and the mineralogical data was obtained on powdered sample using XRD instrument. The analysis showed that the granitic igneous rock obtained from klington quarry consists coarse grains of quartz at 50%, 13 % Orthoclase (potassium feldspar), and about 9 % of Anorthite. These minerals make up more than 75% of the rock. Volcanic rock of equivalent chemical composition and mineralogy is called rhyolite.

2.3 DTA MEASUREMENTS

Thermal behaviour was measured on a DSC/TGA at a heating rate of 4, 8, and $12^\circ\text{C}/\text{min}$ in an oxidation firing, over the temperature range from 25 to 1300°C . DTA is considered to be a great tool to predict the process and condition to obtain ceramic material from granite residue. DTA thermo gram exhibited endothermic and exothermic events. It showed types of carbonates, silicates and an endothermic peak (567°C) is suggesting the polymorphous transformation of a-quartz into b-quartz and also indicating the sintering (solid/liquid) at 1125°C (near melting, T_m).

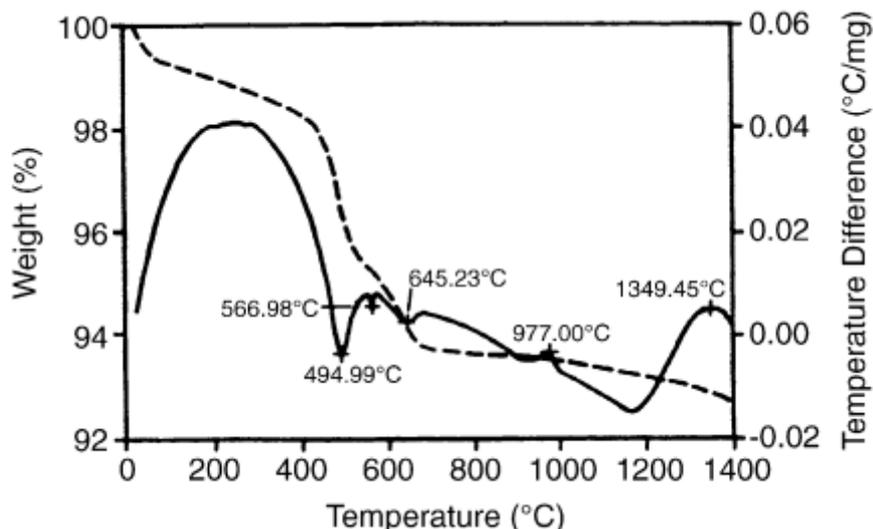


Figure 1: DTA Curve of Granitic Igneous Rock (Heitor 2001)

2.4 SUGGESTED BATCH COMPOSITION

Most food safe glaze recipes are compounded from combination of feldspar which acts as a flux, kaolin a source of alumina and silica the glass former. The method adopted for this research was blending different granitic igneous rock powders with clay powders selected from Ikere Ekiti, at different percentages and mixed by hand with the aid of water since the quantities desired for experimentation is small. Batches obtained were painted on ceramic test tiles so as to determine their ability to behave like a functional glaze. The test tiles was eventually placed in furnace and heated to a temperature of 1250°C for 6 hours. The most promising result with a very minimal glaze defects like crawling, and crazing came from composition G4 “40% granite, 50% ash and 10% china”.

Table 2: Batch Composition

Composition	G1	G2	G3	G4	G5
Granite	70%	60%	50%	40%	30%
Wood Ash	20%	30%	40%	50%	60%
China Clay	10%	10%	10%	10%	10%

Source: Authors Field Work

3 CONCLUSION

Granitic igneous rock is a potential and viable additional raw material suitable for the production of ceramics glazes, from the chemical analysis conducted on the waste granite dust picked from the quarry site; it’s pertinent that granite has a double composition of feldspar and other metallic oxides which will successfully act as a strong flux in glaze composition. The glaze batch composed with line blends of powdered granitic igneous rock and wood ash in addition of 10% china clay showed promising glaze composition that is void of feldspar at stoneware temperature.

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