Developing Medium Range Temperature Glazes Using Locally Sourced Raw Materials

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Abstract
Ceramic raw materials utilization and development which include glazes are of great importance in ceramic production. Ceramic glaze materials when subjected to heat treatment become glassy, mechanically strong smooth to touch, hygienic, Impervious to liquids, and aesthetically appealing to the eyes. Glazes are imported into the country because there is no ceramic glaze manufacturing company in Nigeria. And because they are imported the glazes are very expensive. Large scale, small scale industries including studio potters depend on imported glazes. This situation has contributed immensely to good number of existing large and small scale industries to go moribund. The carbonated, zinc oxide, feldspar, flint and kaolin to produce medium range temperature glaze. The materials were tested in various sample glazes compounded. Sample number six was adopted and subjected to gloss firing using cone 3, (1140°C). The glaze melted well without crazing, crawling or pinholes. The study recommends the utilization and integration of locally sourced ceramic raw materials in glaze development. This will not only encourage ceramics. It will help to revamp the moribund industries. It will reduce production cost and sustain national development.

Introduction
Glaze is an important component in ceramic production with regards to making a pottery ware impervious, smooth, hygienic, aesthetically appealing, resistant to chemical attack and mechanically stronger. In present day Nigeria, people want to make use of wares that are well decorated and functional, but the Nigerian cottage ceramic industries have not been doing well in the development and utilization of locally sourced raw materials for production of attractive 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 cottage ceramic industries and individual potters alike in Nigeria, a situation that compels many ceramic graduates to abandon their profession for white collar jobs or trade. 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 beneficiated raw materials is low. The Director General/Chief Executive Officer of Raw Materials Research and Development Council, Prof. Azikiwe Onwuala in Jennifer (2012) reveals that the local demand for ceramic product in Nigeria is very high, considering the country's population of over 140 million. He estimated that about ₦5billion is currently

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spent annually on ceramic importation. The chairman, Apapa branch of the manufacturers association of Nigeria, John Aluya also mentioned at a stakeholder forum in 2009 that about 50 containers of ceramic products come into the country daily, in spite of both raw materials and human capacity for its production in Nigeria.

However, even as the demand for ceramic products is rapidly increasing with increase in population and activities in the construction industries, yet ceramic production in Nigeria does not seem to have been impacted positively. Instead, many ceramic industries in Nigeria have either gone moribund or not producing to full capacity for lack of good glaze. At exhibition each year by members of Ceramic Researchers Association of Nigeria it has also been observed that many wares that are exhibited by member who are mostly from the academia are either not glazed or painted with oil colour in place of glaze probably due to inability to prepare glazes by some of the exhibitors. This situation is worrisome since Nigeria is blessed with abundant raw materials and these are largely yet to be tapped. Akinbogun (2004) remarked that ceramic raw materials are not in the list of problems confronting ceramic industries in Nigeria but that of raw materials processing and their optimization, including glaze production. Available data from Raw Materials Research and Development Council, Abuja, as reported by Chigbo (2009), and Kashim (2011) reveal that there is abundant of ceramic materials in Nigeria. Oyeoku (1999), also reports that virtually all the consumable ceramic raw materials needed to sustain the sector can be derived locally. This suggests that the low level local investment could not have been due to lack of raw materials.

There are therefore the abundance of feldspar, calcium carbonate, silica/flint from Okpella in Edo state. And so also are colourants such as iron oxide, manganese, tin oxide and cobalt from local outlet.

Glaze Preparation

Glaze should be prepared in a systematic manner to prevent mistake. Since problems encountered with glaze composition arise from incorrect weighing, mistakes in identifying raw materials and not sieving the glaze to a desirable finest particles sizes (200 mesh sieve). Mistakes in glaze formulation are expensive as they can result in loss of entire kiln load of ceramic wares for this reason, careful procedure becomes important in composing, mixing and milling the glaze materials as well as sieving to at least 120 mesh because finely ground materials melt more easily in glaze.

It is advisable that glaze test should be carried out on test tiles or text mugs before using them on big wares (Anderson, 2001). To determine the suitability of the sample, raw materials for the glaze development in terms of melt without flaws such as crawling, crazing, or pinholing. The materials were tested in various sample glazes compounded. Sample number six was adopted and subjected to gloss firing using cone 3. (1140°C)

Sample Number	Potash Feldspar	Whiting	Zinc Oxide	Kaolin	Flint
1.	20	15	5	15	45
2.	45	15	10	6	24
3.	59.5	10.3	12.5	8.6	19.1
4.	44.8	10.7	3.7	6.9	25.8
5.	43.0	9.3	16.6	8	24.1
6.	52.3	15.7	5.1	8.1	18.8
7.	30	20	10	10	30
8.	30	10	5	5	50
9.	39	13	10	8	30
10.	40	10	13	5	32

The ten test samples recordCalculation of the glaze formular of glaze recipe, serial number six (6) adopted for this research

Feldspar - 52.3
Whiting - 15.7
Zinc Oxide - 5.1
Kaolin - 8.1
Flint - 18.8

Materials	Molecular weight	Molecular part	Part by weight	K_2O	Cao	Zno	Al_2O_3	SiO_2
Feldspar	556.5	0.094	52.3	0.094	-	-	0.094	0.564
Whiting	100	0.157	15.7	-				
Zinc Oxide	81.4	0.063	5.1			0.063		
Kaolin	258	0.031	8.1				0.031	0.062
Flint	60	0.313	18.8					0.313
				0.094	0.157		0.125	0.939

Divide part by weight with molecular weight

0.094 - K_2O
0.157 - Cao
0.063 - Zno
0.314

0.125$Al_2O_3$0.939 -SiO_2

K_2O = 0.094 ÷ 0.314 = 0.30
Cao = 0.157 ÷ 0.314 = 0.50
Zno = 0.063 ÷ 0.314 = 0.20
Al_2O_3 = 0.125 ÷ 0.314 = 0.40
SiO_2 = 0.939 ÷ 0.314 = 3.0

1.00 unity

The sum of the basic oxide must add of up to 1 (one) or unity
The glaze is
0.30 K_2O
0.50 CaO
0.20 ZnO

0.40 Al_2O_3

3.0 SiO_2

Given the glaze formular , when also calculated or by percentage composition the same answers or figures were arrived at

0.30 K_2O
0.50 CaO
0.20 ZnO

0.40 Al_2O_3

3.0 SiO_2

Materials	Molecular weight	Molecular part	Part by weight	K_2O	CaO	ZnO	Al_2O_3	SiO_2
Feldspar	556.5	0.30	166.9	.30	-	-	.30	1.8
Whiting	100	0.50	50.0	-	.50			
Zinc Oxide	81	.2	16.2			.02		
Kaolin	258	.1	25.8				.1	.2
Flint	60	1.0	60					1.0
			318.9	.30	.50	.02	.40	3.0

Feldspar = $\frac{166.9}{318.9}$ x 100 = 52.3%

Whiting = $\frac{50.0}{318.9}$ x 100 = 15.7%

Zinc Oxide = $\frac{16.2}{318.9}$ x 100 = 5.1%

Kaolin = $\frac{25.8}{318.9}$ x 100 = 8.1%

Flint = $\frac{60}{318.9}$ x 100 = 18.8%



Plate 1: Weighing of test composition into batch



Plate 2: Ball milling of the glaze

Five objectives were cardinal in examining materials that can be sourced locally. **F**ield trip was made to Okpella where feldspar and flint and calcium carbonate (whiting) were obtained already milled. The tin oxide, manganese, zinc oxide and cobalt were obtained from a local retail outlet at Auchi, while the kaolin was obtained from Afowa close to Auchi. During the visit to Okpella it was observed that the village had these materials in abundance, enough to serve the ceramic industries for a very long time to come if properly harnessed. They can even be processed for export.

In order to determine the suitability of the raw materials ten samples of glazes were formulated with feldspar, whiting, zinc oxide, flint and kaolin as base glaze and subjected to firing using gas at the Department of Ceramics in the School of Art and Industrial Design, Auchi Polytechnic, Auchi. The test pieces were fired to 1160^0C. The tests were also fired in gas kiln to 1160^0C.

After the firing it was observed that the test sample 1 and 8 did not fuse, sample 2, 7,9 and 10 fused but did not melt while sample 4 and 5 melted but were matt in appearance. Sample 3 and sample 6 fused very well and were glossy producing various ranges of brown colour. The results may be attributed to the prominence of feldspar in the mixture including the type of clay body the test globe was applied on.

The result showed a good prospect and suitability of locally sourced raw materials in glaze production devoid of crazing. This is a very good sign that the glaze adhered properly to the clay body. The subjection of the glazed test pieces in gas kiln to 1160^{0}C assisted at addressing research question 1,2 and which indicated that locally sourced raw ceramic material are not only suitable for development of glazes, they also fuse and melt properly to clay ware without serious flaws.

Attempt was also made to produce a glaze that will melt between 11000C and1190^{0}C. This was to affirm the possibility of producing glaze that will melt properly. Test was fired to 1160^{0}C. The actual batch glaze was milled for about sixteen (16) hours; eight hours each day for two days. Of the various tests sample test number six was further milled for about sixteen 16 hours using the ball mill. The quality of glaze appearance was improved and the melting time also reduced greatly from 1160^{0}C to 1130^{0}C - 1140^{0}C. In all, four gloss firings were carried out within three hours fifteen minutes each, using the gas kiln.



Plate 3: Glazing – dipping



Plate 4: Glazing- pouring



Plate 5: Inspecting the firing

The physical characteristics of the glazes were also examined. The batched glaze was subjected to series of gloss firings and the batched glaze was also applied on different clay bodies at different times to ascertain the glaze physical characteristics. At 1140^0C it was observed that thick application especially of the opacified glaze with tin oxide did not melt properly when compared to the test on which the glaze was thinly applied. The colour resulting from the addition of cobalt oxide in the first glaze firing gave a rather harsh blue. But the addition of iron oxide beautifully varied the blue colour in further tests. The glaze did not craze. It did not crawl, and it did not run.



Plate 6: Casserole Dishes



Plate 7: “Help”



Plate 8: Cast vases

One question that has readily come to mind here is: what is the cost implication, working with locally sourced materials? There is no gainsaying the fact that it was economical to produce ceramics with locally sourced glaze. The needed glaze materials for ceramic glaze production are available in abundance. One of the major ingredients of glaze development also readily available locally is the flux which was used to influence the characteristics and aesthetic value of the glaze through percentage manipulation. With the right kiln, a properly prepared local glaze will vitrify at the desired temperature. The 50kg bag of feldspar, flint, calcium carbonate (whiting) used as base or transparent glaze for the

research were sourced from Okpella and Auchi respectively with less than six thousand (N6,000) Naira. Out of this less than five thousand (N5, 000) Naira worth of the materials were used for the research, the opacifier and colourant inclusive. Only 20kg batch of glaze was prepared and used in the course of the research. Four glost firings were carried out in the gas kiln using 50kg gas bought from a gas plant at Auchi at the rate of fifteen thousand (N15,000) Naira only. In totality less than twenty thousand (N20, 000) Naira was used in carrying out four different glost firings to 1140^0C, cone 3. Compared to the present exchange rate of over four Hundred (N400) Naira to one US dollar, the total cost of glaze used for the for the investigation and the four glost firings would have come to about 12.5 USD.

Conclusion

It is an unmistakable fact that Nigeria is blessed with an abundance of materials for ceramics production, including glazes. As with the northern part of Edo State, these materials can be found in various other parts of the country too. It is perhaps important to note that addition of tin oxide to base glaze that contains zinc oxide produces a good quality opaque glaze. However, it requires thin or light application of the opacified glaze to avoid bloating.

Exploitation of these locally available materials will no doubt liberate large and small scale ceramic industries, studio potters and student of ceramic in various tertiary institutions from the present dire situation with respects to ceramic production in Nigeria, as these materials are largely imported presently. Investment in the harnessing of these materials rather than the present dependence on importation will no doubt have a positive rippling effect. Their availability would be guaranteed and the present shortages would have been brought to an end. This ensures continued glazing of their wares by ceramics producers, including small, medium, and large scale.

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