THE USE OF WASTE INJECTION VIALS AND AMPOULES FOR FORMULATING A STABLE CERAMICS GLAZE

[1]OGUNDARE T.S, [2] AKINBOGUN T.L [3]KASHIM I.B
Department of Industrial Design
Federal University of Technology AKURE

ABSTRACT
Glaze making in Nigeria has not been encouraging, therefore making the act of glazing going into extinct. This is due to unavailability of required fluxes for firing ceramic wares at low temperature. Meanwhile glass of different properties like Grade B borosilicate and Soda-Lime Silica glasses which contain the required silica/flux for formulating low temperature glazes are abundantly available as waste, which pollutes the immediate environment. This paper therefore discuss the availability and utilization of different types of waste glasses in their properties for formulating ceramic glazes by processing and sieving the waste glasses into their finest particle called cullet. Cullet was used as a source of flux/silica with kaolin/ ball clay supplying the alumina for stabilizing the glaze. Cullet was composed in several proportions with ball clay in ratio 1-10 and vise – versa. The composed glazes were fired at different temperature and atmosphere to detect the best condition at which cullet can be utilized as a source of silica/flux in formulating a ceramic glaze.

Introduction
The science and art of clay making which eventually pass through fire is still of great importance to man, take for instance corrosion resistance, chemical inertness, and thermal shock resistance (Youssef, Abadir, and Shater, 1998) Its imperative values have made it possible that man can hardly live without ceramics product around him to the extent that it is called a strong-fragile part of human life. Today it will be hard to imagine the consequence of a world without ceramics, a world without bricks, tiles, pottery and refractory necessary to withstand the high temperatures in melting of metals and the melting of glass. Ceramics is found to be essential to man in day to day life; though cumbersome and difficult in making but has a high aesthetic value after production.

In making ceramics, silicon is found to be very important both at biscuit and gloss temperature since it forms the principal material needed for sintering or conversion to glassy state. During glass production, the principal raw material used is silica which comes in several compounds of silicates, melted and formed to shape at high temperature, with addition of several compounds called fluxes a catalyst that accelerates the melting temperature of the silica at fairly lower temperature. Wright (1987) notes that manufacturing process of ceramics comprises excavation of raw materials which is mixed together in different ways to form bodies and glazes; it is the interaction between the bodies and glazes after firing that brings about its attractiveness and properties which make it useful to man in every ramifications of life. Similarly such raw materials are excavated and used for glass processing and production. The waste from glass formation processes and used glasses and cullets are recycled for further production in to pulverized fine grains.

Cullet is a name given to waste broken glass which contains the major materials required for glaze preparation. Glaze is described according to Fournier (1976) as a special sort of glass differing from window-glass and glass ware in its lower thermal expansion and higher alumina content, which increase its viscosity and help it to adhere to the clay

body. Most Cullet consists mainly of silicon, sodium, and calcium oxides (referred to as soda-lime-silica glass) with other minor components, such as aluminium and magnesium oxides just to improve its viscosity.

Flux is a term applied to those compounds that lower the melting point of a glaze; although many chemicals with a low melting point will also readily combine with silica to form a glassy crystal. Ryan (1978) describes flux as a material which lowers the fusion temperature of the mixture to which it is added. But getting the required flux for making glaze could be difficult sometimes since available fluxes for producing leadless low temperature glazes are imported at colossal rate and thorny to get for contemporary studio potters and ceramic students. Meanwhile all the essential fluxes needed in making glaze are also used for making glasses which have turn to waste materials in the environment.

The potential of replacing natural fluxes with cullet has been reported in Youssef, et al. (1998), Tarvornpanich (2006). This underscore the importance of recycling cullet which will not only turn waste to wealth but will also reduce the stress and cost of seeking fluxes for ceramic glazes. Glass is found to be in different types and properties and getting their cullet for exploration will not be too difficult since cullet is more of a nuisance to the environment. For the purpose of this research, exploring the composition and effect of cullet of different properties will be the major means of flux derivation. In this direction, the use of cullet for total or partial replacement of fluxes in ceramics glazes will be a very promising initiative as it will strongly contribute to sustainable development of ceramics industries in Nigeria, enhance the use of and also sustain the environmental benefits of the society.

Making of Test Tiles

Small test tiles were made for the purpose of testing the glaze behaviours on the surface of the tiles. The green ware (Test Tiles) was allowed to dry completely before it was placed in the kiln. The spy hole was left opened for an hour so as to allow the moisture to escape.

Material Processing and Experimentation

In order to avoid mixture of other impurities with the cullet, care was taken in processing the injection vial to cullet; this was done with thorough washing of the glass so as to remove every dirt, which might serve as impurities in the cullet. The cullet was dried and pulverized ground and ball milled for several hours to make it finer and ready for sieving.

Glaze composition in biaxial blend

In order to formulate suitable glaze from glass, having the idea that glass already contain the required silica and flux needed in formulating a glaze, biaxial blend of glaze composition was adopted as suggested by Singer and Singer (1963). Glass already contains silica which comes as the glass former and also the flux which will reduce the melting temperature. The purpose of conducting the biaxial blend was to determine the best ratio at which cullet will combine with other materials to form a glaze.

The following factors were strictly adhered to during composition

1) Cullet was accurately measured using the three beam balance.
2) Cullet was mixed with the combining materials and sired very well with water been added for thorough mixing.
3) Every composed blend was labelled so as to avoid mix up of any kind
4) Every produced test tiles was also labelled for proper accuracy after firing

Cullet Fired Under Different Temperature and Atmosphere

- First firing at 1100^{o}_{c} was under Reduction Atmosphere
- Second Firing at 1200^{o}_{c} was also under Reduction atmosphere
- Third firing with substitution of Bari kin Ladi Kaolin with Auchi Kaolin and mixture of cullet with other oxides was done in reduction atmosphere
- Fourth firing (Cullet mixed in line blend with base glaze, fired under reduction atmosphere)
- Fifth Firing (recomposing some previous result and fire under

oxidation and reduction atmosphere)

Observations after firing

- It was observed that injection vial formed a glossy opaque glaze with ball clay in ratio 40% of ball clay and $60^{\%}$ of injection vial
- 30%of ball clay and 70% of injection vial
- 20% of ball clay and 80% of injection vial
- 10% of ball clay and 90% of injection vial
- It was observed that most of the composition made with other oxides melted but blistered and bloated
- Feldspar kaolin and injection vial gave a good result but crazed and ran.
- That ball clay produced an opaque glaze with cullet, showing the presence of other oxides in the particular ball clay.
- That rapid reduction firing under a gas kiln produces a bloating and bubbling effect with cullet glazes.

From the listed observations, it was clearly seen that ball clay gave the best result with injection vial at stoneware temperature.

Conclusion

The research has proved that desirable glazes can be made from cullet without addition of any other fluxes. The study has also proved that non-crazing and non-crawling or running glazes can be made from cullet at low temperature. It was also pragmatic from the research that injection vial and ampoules produced essential result when used as a source of silica/flux as compared with the common researches which have centered on the use of soda-lime silica glasses in forming ceramic glazes. The research furthermore showed the expediency of cullet in forming ceramic glazes with its viability as a replacement for frit in existing ceramic glaze batches, which will also reduce the melting temperature of the batch.

Plate 1: Sieving Cullet

Plate 2: Unloading sieved cullet

Plate 3A: Glazed Result

Plate 3B: Glazed Result

RESULTS
TEST FIRING TO 1200^{O}C
Temperature: 1200^{0}C.
Measuring instrument: Thermocouple
Table 1.0 Line blend of Cullet with other materials fired to 1200^{o}c

No	Raw Materials mixed in Line Blend											Melted	No Melt	Melted & Bubbled	Bloated	Bubbled
1		A_3	B_3	C_3	D_3	E_3	F_3	G_3	H_3	I_3	J_3	K_3	K_3 (Melted on its own but Crazed)	$A_3 - G_3$ (samples did not melt)	_	I_3, J_3 (Melted but bloated)	_
	Injection Ampoules	-	1	2	3	4	5	6	7	8	9	10					
	Kaolin	10	9	8	7	6	5	4	3	2	1	-					
2		A_6	B_6	C_6	D_6	E_6	F_6	G_6	H_6	I_6	J_6	K_6	H_6, G_6, J_6 Good Melt	A_6-C_6 (samples did not melt)	I_6	D_6 (Melted but bloated)	E_6, F_6
	Injection Ampoules	-	1	2	3	4	5	6	7	8	9	10					
	Ball Clay	10	9	8	7	6	5	4	3	2	1	-					
3		A_9	B_9	C_9	D_9	E_9	F_9	G_9	H_9	I_9	J_9	K_9	J_9 Melted but ran and crazed	$A_9 - D_9$ (samples did not melt)	I_9	G_9, J_9 (Melted but bloated)	E_9, F_9
	Injection Ampoules	-	1	2	3	4	5	6	7	8	9	10					
	Ball Clay/Kaolin	10	9	8	7	6	5	4	3	2	1	-					
4		A_{12}	B_{12}	C_{12}	D_{12}	E_{12}	F_{12}	G_{12}	H_{12}	I_{12}	J_{12}	K_{12}	I_{12}, J_{12}, H_{12} Melted but ran and crazed	A_{12}–D_{12} (samples did not melt)	_	F_{12} (Melted but bloated)	E_{12}, G_{12}
	Injection Vial	-	1	2	3	4	5	6	7	8	9	10					
	Feldspar	10	9	8	7	6	5	4	3	2	1	-					

5		A_{15}	B_{15}	C_{15}	D_{15}	E_{15}	F_{15}	G_{15}	H_{15}	I_{15}	J_{15}	K_{15}	$I_{15,}$ J_{15} Melted but ran and crazed	_	_	$E_{15,}$ F_{15} (Melted but bloated)	$G_{15,}$ H_{15}
	Injection Vial	-	1	2	3	4	5	6	7	8	9	10					
	Feldspar/Kaolin	10	9	8	7	6	5	4	3	2	1	-					
6		A_{18}	B_{18}	C_{18}	D_{18}	E_{18}	F_{18}	G_{18}	H_{18}	I_{18}	J_{18}	K_{18}	_	A_{18}–D_{18} (samples did not melt)	_	$E_{18,}$ F_{18} (Melted but bloated)	$G_{18,}$ H_{18} ,$I_{18,}$ J_{18}
	Injection Vial	-	1	2	3	4	5	6	7	8	9	10					
	Whiting/Kaolin	10	9	8	7	6	5	4	3	2	1	-					
7		A_{21}	B_{21}	C_{21}	D_{21}	E_{21}	F_{21}	G_{21}	H_{21}	I_{21}	J_{21}	K_{18}	_	_	I_{21} J_{21}	E_{21} F_{21} (Melted but bloated)	$G_{21,}$ H_{21}
	Injection Vial	-	1	2	3	4	5	6	7	8	9	10					
	Dolomite/Kaolin	10	9	8	7	6	5	4	3	2	1	-					

References

Akogun, O.B (2000) *Researchers Manual*. Yola Nigeria Paraclete Publishers.

Cardew, M (1969): *Pioneer Pottery*. London, Longman, Group Limited. Pg 156

Carty, W.M., 2002, *Observation on the Glass Phase Composition in Porcelains*. Chem. Eng. Sci. Proc. Pg 65

Cooper & Derek (1978). *Glazes for the Studio Potter*: Courier International Ltd. Great Britain.

Fournier, R. (1976): *Illustrated Dictionary of Practical Pottery*. New York, New van Nostrand Reinhold Company

Irabor, P.S (2007): From Pottery Art to Ceramic Science and Technology: Educational and Industrial Perspective in Nigeria. Ashaku Journal of Ceramics, Vol 1 No 1 Dasma Press Zaria, Nigeria

Nelson G.C (1984) *Ceramics: A Potters Handbook*. Orlando: Harcourt Brace Collage Publishers

Norsker. H (1989). *Self Reliant Potter*. GATE Press. Tanzania, Pg 47

Norsker. H (1989). *Glazes for Self Reliant Potter*. Tanzania Pg 72

Rado P (1969) *The Technology of Pottery*. London Pergarmon Press.

Rhodes, Daniel (1981): *Clay and Glazes for the Potter*. London Macmillan books

Ryan Williams (1978). *Properties of Ceramics Raw Materials*. Pergarmon Press Ltd Headington Hill Hall, England.

Singer, F. And Singer S.S. (1963): Industrial Ceramics Chapman and Hall Ltd. Surrey

Tarvornpanich, T.(2006), Recycled *Colourless Soda-Lime-Silica Glass as an Alternative* Flu*x in Whitewares*, PhD Thesis, University of Sheffield.

Wright, R.T (1987): Manufacturing Systems. The Good heart-Wilcox. Comp.Inc

Wikipedia "The Free Encyclopedia" (2009):Soda-lime glass . Retrieved date: May 10, 2010 . http://en.wikipedia.org/wiki/Soda-lime_glass

Youssef, N.F., Abadir, M.F. and Shater, M.A.O., 1998, "*Utilization of Soda Glass (Cullet) in the Manufacture of Wall and Floor Tiles*", *J. Euro. Ceram. Soc*.