The Effects of Banana Ash, Vigan Clay, DT, and Other Oxides in Glazing Terra Cotta Vases

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Abstract

This study was focused on determining the effects of banana ash (Ba), Wigan clay (), and DT mixed with cobalt oxide (CoO), iron oxide (FeO), and manganese dioxide (MnO2) in glazing terra cotta vases in terms of the appearance, texture, and color of the test pieces after firing at 1020°C.

The results of this study showed that the formulations of banana ash, Wigan clay, and DT mixed with cobalt oxide except CI5 (35-15-75-5 BaVD + CoO) produced blue violet and Victoria blue frited tile samples, with rough surfaces. Among the BaVD formulations with iron oxide, all the formulations except FI, F2, and F4 yielded test pieces that were rated gloss point in appearance and had smooth surfaces. Three colors were produced by the formulations of BaVD with iron oxide, namely: brow, spumako camel, and chocolate brown. All the tle samples glazed with 16 BaVD formulations mixed with manganese dioxide were rated gloss point in appearance, had smooth surfaces, and two colors were produced, namely: cypress brown and spumako camel. Therefore, it was concluded that among 48 formulations of banana ash, Wigan clay, and DT, mixed with these different oxides, the formulations mixed with manganese dioxide yielded the best results in glazing terra cotta vases.

Introduction

Background of the Study

Ash was one of the first materials developed for high-fired ceramic glazes. Its use as glaze was discovered accidentally when during firing, ash from the wood fire drifted into the kiln chamber and landed on a pot The fluxes, magnesia, and calcium in the ash fused with the silica in the clay to for a glaze on the shoulders and exposed areas of the pot.

Ash glazes are generally derived from wood, rice straw, grasses, and other organic materials. When these are bumed, they leave a powdery residue that can also serve as an ash glaze base. The mineral content of different ashes varies enor:mously. For example, the trunk wood of an apple tree has more calcium than an old trunk; the trunk of **the new** young growth has less silica than an old trunk; 1he wood in spring has more calcium and alkaline. Some of the most interesting ash glazes can be found (and test can be obtained easily and inexpensively) in a fire place and incinerator ash. Because of the variety of items which are bumed and become part of ash, one never knows what sort of glaze may result

The recipe on the batch formula was utilized in the method of calculation on the ingredients of the glaze. The total of the weights in the recipe is the batch weight.

This study describes the processes in the preparation of the glaze, mixing, and firing the test pieces as done in the Ceramics Research Productivity Center (CRPC) of the University of Norther Philippines (UNP), Vigan, locos Sur from January 1998 to March **1999.**

This study was the first investigation on glaze formulation used in glazing terra cotta vases made particularly in *Vigan,* Ilocos Sur.

Objectives

This study attempted to find out which of the different formulations of banana ash, Vigan clay and DT, mixed with the different percentages of oxides would yield to an effective glaze for terra cotta vases.

I sought answers to the following questions:

1. Which of the different formulations of banana ash (Ba), Vigan clay (V), and DT,, (D) with cobalt oxides (CoO) would yield an effective glaze for tera cotta vases in terms of appearance, texture, and color?

2. Which of the different formulations of banana ash (Ba),Vigan clay (V), and DT D) with iron oxide (FeO) would yield an effective glaze for tenra cotta vases in terms of appearance, texture, and color?

3. Which of the different fonnulations of banana ash (Ba), Vigan clay (V), and DTA (D) with manganese dioxide (MnO,) would yield an effective glaze for terra cootta vases in terms of appearance, texture, and color?

Scope and Delimitation

This study was focused on the effects of banana ash (Ba), Vigan clay V), and DTA, D) mixed with either cobalt oxide (CoO), iron oxide (FO) or manganese dioxide (MnO,) in glazing tera cotta vases.

It was limited to the analysis of 48 formulations of these clay materials that would yield the best appearance, texture, and color of terra cotta vases. Sixteen of these were formulations of BaVD mixed with 2-5% of cobalt oxide (CoO) plus 40 ml water (fable l). Sixteen were formulations of BaVD mixed with 2-5% of iron oxide (FeO) plus 40 ml water (Table 2). Another set of 16 formulations were combinations of BaVD mixed with 2-5% of manganese dioxide (MnO3) plus 40 ml water (Table 3).

Table L. Mixing formulations of banana ash, Vigan clay, and DT3a with cobalt oxide analyzed in the study.

FORMULATION	GLAZE MATERIAL Pe			
	BANANA ASH (Bas)	VIGAN CLAY (V)	DT3,D)	COBALT OXIDE (CoO)
Cl	45	05	15	2
c2	40	10	15	2
C3	35	15	15	2
CA	30	20	15	2
C5	45	05	15	3
C6	40	10	15	3
C7	35	15	75	3
C8	30	20	75	3
C9	45	05	15	4
CI0	40	10	75	4
ClI	35	15	75	4
Cl2	30	20	75	4
Cl3	45	05	75	5
C14	40	10	75	5
Cl5	35	15	75	5
CI6	30	20	15	5

Table 2. Mixing formulations of banana ash, Vigan cday, and DT,, with iron oxide analyzed in **the study.**

FORMULATION	GLAZE MATERIALG			
	BANANA ASH (Ba)	VIGAN CLAY (V)	DT, D)	IRON OXIDE FeO)
Fl	45	05	75	2
F2	40	10	75	2
F3	35	15	75	2
F4	30	20	15	2
F5	45	05	15	3
F6	40	10	15	3
F7	35	15	75	3
F8	30	20	75	3
F9	45	05	75	4
FI0	40	10	75	4
Fll	35	15	75	4
Fl2	30	20	15	4
Fl3	45	05	75	5
FI4	40	10	75	5
FI5	35	15	75	5
Fl6	30	20	75	5

Table 4. Mixing formulations of' banana ash, Vigan clay, and DTu with manganese oxide analyzed in the study.

FORMULATION	GLAZE MATERIAL (Percent) BANANA ASH (Ba)	VIGAN CLAY V	DT, D)	MANGANESE DIOXIDE (MnO)
M1	45	--	75	2
M2	40	10	75	2
M3	35	15	75	2
M4	30	20	75	2
M5	45	05	75	3
M6	40	10	75	3
M7	35	15	75	3
M8	30	20	75	3
M9	45	05	75	4
M10	40	10	75	4
M11	35	15	75	4
M12	30	20	75	4
M13	45	05	75	5
M14	40	10	75	5
M15	35	15	75	5
M16	30	20	75	5

Review of Related Literature

Speignt (1976) states that modem chemistry has given the potter much useful information about the behavior of glaze materials. However, the potter still depends on trial and error and testing. Slight changes in the amount of certain ingredients can change a glaze radically, and there is no way to be sure what a particular glaze will look like without making a test or series of tests. Tests allow the researcher to alter the proportion of one material slightly and see what happens to the glaze. At all times potters, no .... how experienced, test constantly, always looking for new and better glaze formulas.

Speignt further states that in making the ingredients, a potter must use a balance scale, weigh out the dry ingredients, then add them to a small quantity of water to form a thick, soupy mixture. Next he must put this mixture on a sieve with 60 or 80 mesh, refine the materials and mix them thoroughly. Then, he should add more ...... to bring the mixture to a good consistency for dipping or brushing the glaze onto the articles– a mixture like thick cream is generally satisfactory. Many potters use a hydrometer to measure the .... By doing this, they can make the water .... and the glaze at the same consistency at all times, adding more ...... as it evaporates. Mix the ingredients thoroughly and continuously or else the solid ingredients will settle at the bottom.

Costales and Olson (1959) states that the materials for glaze must be property prepared to be usable. This preparation when done in a ceramics materials industry includes filtering, chemical purification, and such processes specially designed for machines and equipment that prepare the materials automatically. But when the preparation is done by hand or with inadequate facilities, only crushing, grinding, pulverizing, washing, and screening may be possible. Crushing can be done with a heavy hammer until the largest piece is as small as match head The grinding and pulverizing can be effectively done with the use of a porcelain mortar and pestle. The particles of most ceramic materials should be fine enough to pass through a 200-mesh or fiber screen. Wire screen or nylon-lawn are available for this purpose. When such a screen is not available the grindings should be sieved through at least 10O mesh. Then, they should be ground further until they had been reduced to a powder which feels as soft as four. When any grittiness can be felt between the finger tips the material is too coarse. Washing the powder with several rinses of water will remove undesirable materials which come to the top.

Methodology

Research design, This study used the experimental method of research observing the operational procedures.

Materials and tools/equipment. Table 4 presents the materials and tools/equipment used in this study and their functions.

Table 4. Materials and tools/equipment used in **the study and their functions.**

MATERIAL AND TOOL/EQUIPMENT	USE AND OTHER DETAILS
Banana Ash (Ba)	One of the ingredients of the base glaze for terra cotta vases.
Cobalt oxide (CoO)	Used to give blue color to glass and pottery ware, and added to groundcoat enamels for steel to improve their adherence.
	A transparent glaze to be added to the base glaze for terra cotta vases
Ferrous oxide (FeO)	This lower oxide tends to be formed under reducing conditions; it will react with SiO to produce a material melting at about 12000C hn this study, it is the same as iron oxide.
Manganese dioxide (Mn0)	It is used as a coloring oxide (red or purple). When mixed with the oxides of Co, Cu, or Fe, it produces black.
Vigan clay V)	To be added to the base glaze made of banana ash and DT

Table 4. Continued.

MATERIAL AND TOOL/EQUIPMENT	USE AND OTHER DETAILS
Water	To be added to the glaze ingredients to enable the glaze to stick to the articles. In this study, 40 ml *HO* was used in each formulation.
Basin	Used as container of the ingredients of glaze.
Graduated cylinder	Used in measuring the amount of water needed in the mixture of glaze.
Plastic cups	Used for placing the sample ingredients of glaze for tera cotta vases
Sponge (wet)	Used for cleaning the bottom of the articles after glazing to be free from glaze
Spoon	Used fur scooping the ingredients of glaze to be placed on the weighing scale (trial beam).
Weighing scale	Used for measuring the required amount of glaze ingredients for glazing terracotta vases.
Kiln	A high temperature installation used for firing ceramic wares or for calcining.

Definition of Terms

Appearance. In this study, it refers to either fitted or gloss point.

Color. It was based from the mariwasa tile samples.

FHit. This forms an important part of the batches used in compounding enamels and glazes. The purpose of this pre-fusion is to render any soluble and/or toxic components insoluble by causing to combine with silica and other added oxides. In this study, it shows that the glaze was not able to reach its melting point.

Gloss point. When a layer of *glaze* powder is heated, a temperature is reached at which the surface changes its appearance from dull or bright.

Texture. In this study, it refers to the smoothness of the surface of the article/product.

Technical Description of the Process

Basically, seven steps were followed in the preparation of the formulated glaze, namely: pulverizing; weighing; mixing, screening, glazing; firing, and evaluation.

The preparation of the glaze was done through experimentation having of 48 formulations in order to find out which among the formulations (Tables 1-3) has the best appearance, texture, and color. Three sample tiles per formulation were tested

The base glazes were: banana ash (Ba), Vigan clay (V), and DT (D). The oxides needed in the formulations were: cobalt oxide (CoO), iron oxide (FeO) and manganese dioxide (MnO_2).

Pulverizing, This was done by putting two spoonfuls of banana ash into the mortar and pounding it with a pestle until such time that all the banana ash became powder-like. Vigan clay was also pulverized similarly.

Weighing. The required amount of base glaze was weighed and then placed into the plastic cups. Likewise, the required amount of oxides was weighed and put into the plastic cups. Each plastic cup was marked accordingly for evaluation purposes.

Mixing. In mixing the glaze, a graduated cylinder was used to measure the water content of the *glaze* in order to ensure the right amount of water and keep the glaze at the same consistency at all times. Water was added to the dry ingredients in the plastic cups. The ingredients were stirred thoroughly with a piece of stick or an electric device to make sure that heavier glaze ingredients do not accumulate at the bottom.

Screening. Screening was done by using 200 mesh screen to remove foreign particles in the mixture. After screening, the glaze was put into plastic cup, the screen was cleaned to be ready for the next mixture.

Glaze application. Tests pieces should be free from dust and be handled minimally to avoid soiling them with oily fingerprints. The test pieces were wiped with a dump sponge or rinsed quickly under tap water. Then, they were marked at the bottom similarly to the mark on the plastic cups. The glaze was stirred and the article was dipped into it for two to three seconds. Then, the article was shaken to get rid of extra glaze. When finger marks were left on the piece, this was covered by retouching it with a brush.

Gaze firing. After the test pieces were applied with glaze, they were dried and prepared for glaze firing, Before loading the kiln, the researchers made sure that it was clean and that the brick kiln lining had no loose fragments that can full on the articles.

The kiln was loaded and the kiln shelves were on posts to fit around the articles. The tests pieces and other articles inside the kiln were properly arranged and maintained at ▾ distances to prevent the articles from sticking to each other when the glaze melted.

After the kiln was loaded, it was covered, the thermocouple was put, and the kiln was switched on. Between three to four hours of firing, the researchers observed and read the temperature scale, When the temperature reading was 1020C the kiln was switched off. After 12 hours from the start of firing the kiln was opened and the test articles were unloaded.

Evaluation. This was done by arranging the test pieces according to their tag marks. They were checked individually and data on the appearance, texture, and color of each piece was recorded. The results were analyzed and interpreted.

Results and Discussion

Characteristics of Tile Samples Glazed with Formulations Having Cobalt Oxide

Appearance. Of the 16 formulations of banana ash (Ba), Vigan clay (V), and DT3 D) with cobalt oxide (CoO) used to glaze tera cotta vases, only Formulation C15 (35-15-75-5 BaVD + CoO) produced tile samples rated GP or gloss point. All other tile samples glaz.ed with the other formulations produced fritted or underfired test pieces (Table 5).

Table 5. Appearance of the tiles samples glazed with 16 formulations of banana ash, Vigan clay, and DT, with cobalt oxide.

FORMULATION	CHARACTERISTIC		
	SAMPLE 1	SAMPLE 2	SAMPLE 3
C1 (45-05-75-2 BaVD+CoO)	F	F	F
C2 (40-10-75-2 BaVD+CoO)	F	F	F
C3 35-15-75-2 BaVD+CoO)	F	F	F
CA 30-20-75-2 BaVD+COO)	F	F	F
C5 (45-05-74-3 BaVD+CO)	F	F	F
C6 (40-10-75-3 BaVD+CoO)	F	F	F
C7 35-15-75-3 BaVD+CoO)	F	F	F
C8 (30-20-75-3 BaVD+COO)	F	F	F
9 (45-05-75-4 BaVD+CoO)	F	F	F
C10 (40-10-74 BaVD+CO)	F	F	F
C1 35-15-74 BaVD+CoO)	F	F	F
C12 (30-20-754 BaVD+CoO)	F	F	F
C13 (45-05-75-5 BaVD+CO)	F	F	F
C14 (40-10-75-5 BaVD+CoO)	F	F	F
CI5 35-15-75-5 BaVD+CO)	GP	GP	GP
CI6 (30-20-75-5 BaVD+CoO)	F	F	F

Legend: F – Fritted GP – Gloss point

Texture. Table 6 shows that Formulations C9, CI1, C12, C14 and CI5 yielded smooth test pieces. All the other formulations produced rough tile samples.

Table 6. Texture of **tile samples glazed with** 16 **formulations of banana ash,** *Vigan* **clay and DT₂ with cobalt oxide.**

FORMULATION	CHARACTERISTIC SAMPLE 1	SAMPLE 2	SAMPLE 3
C1 (45-05-75-2 BaVD+CoO)	R	R	R
C2 (40-10-75-2 BaVD+CoO)	R	R	R
C3 (35-15-75-2 BaVD+CO)	R	R	R
C4 (30-20-75-2 BaVD+CoO)	R	R	R
C5 (45-05-74-3 BaVD+C0O)	R	R	R
C6 (40-10-75-3 BaVD+Co0O)	.R	R	R
C7 (35-15-75-3 BaVD+CO)	R	R	R
C8 (30-20-75-3 BaVD+CO)	R	R	R
C9 (4505-75-4 BaVD+CO)	S	S	S
C10 (40-10-75-4 BaVD+COO)	R	R	R
C11 (35-15-75-4 BaVD+CoO)	S	S	S
C12 (30-20-75-4 BaVD+COO)	S	S	S
C13 (45-05-75-5 BaVD+CoO)	R	R	R
C14 (40-10-75-5 BaVD+CoO)	S	S	S
C15 (35-15-75-5 BaVD+CO)	S	S	S
C16 (30-20-75-5 BaVD+COO)	R	R	R

Legend: S – Smooth R – Rough

Color. Two colors were produced by the formulations with cobalt oxide, namely: blue violet and Victoria blue. Formulations C1 to C10 yielded blue violet test pieces while Formulations C11 to C16 produced Victoria blue test pieces (Table 7).

Table 7. **Color of tile samples glazed with 16 formulations of banana ash, Vigan clay, and DT₂ with cobalt oxide.**

FORMULATION	CHARACTERISTIC SAMPLE 1	SAMPLE 2	SAMPLE 3
C1 (45-05-75-2 BaVDC0O)	BV	BV	BV
C2 (40-10-75-2 BaVD+COO)	BV	BV	BV
C3 (35-15-75-2 BaVD+COO)	BV	BV	BV
C4 (30-20-75-2 BaVD+COO)	BV	BV	BV
C5 (45-05-74-3 BaVD+C0O)	BV	BV	BV
C6 (40-10-75-3 BaVD+COO)	BV	BV	BV
C7 (35-15-75-3 BaVD+COO)	BV	BV	BV
C8 (30-20-75-3 BaVD+CO)	BV	BV	BV
C9 (45-05-75-4 BaVD+COO)	BV	BV	BV
C10 (40-10-75-4 BaVD+COO)	BV	BV	BV
C11 (35-15-75-4 BaVD+COO)	VB	VB	VB
C12 (30-20-75-4 BaVD+COO)	VB	VB	VB
C13 (45-05-75-5 BaVD+COO)	VB	VB	VB
C14 (40-10-75-5 BaVD+COO)	VB	VB	VB
C15 (35-15-75-5 BaVD+COO)	VB	VB	VB
C16 (30-20-75-5 BaVD+CO)	VB	VB	VB

Legend: BV – Blue violet VB – Victoria blue

Characteristics of Tle Samples GHazed with Formulations Having Iron Oxide

Appearance. Table 8 shows that of the tile samples glazed with formulations, of banana ash, Vigan clay, DT,, and iron oxide, only Formulations F1, F2, and F4 yielded ffitted tile samples. All the rest produced test pieces rated GP or gloss point.

Table 8. Appearance of tile samples glazed with 16 formulations of banana ash, **Vigan clay, and DT;a with** iron oxide.

FORMULATION	CHARACTERISTIC SAMPLE1	SAMPLE2	SAMPLE3
FI (45-05-75-2 BaVD+FeO)	F	F	F
F2 (40-10-75-2 BaVD+FeO)	F	F	F
F3 (35-15-75-2 BaVD+FeO)	GP	GP	GP
F4 (30-20-75-2 BaVD+FeO)	F	F	F
F5 (45-05-74-3 BaVD+FeO)	GP	GP	GP
F6 (40-10-75-3 BaVD+FO)	GP	GP	GP
F7 (35-15-75-3 BaVD+FeO)	GP	GP	GP
F8 (30-20-75-3 BaVD+FeO)	GP	GP	GP
F9 (45-05-75-4BaVD+FeO)	GP	GP	GP
FlO (40-10-75-4BaVD+FeO)	GP	GP	GP
F11 (35-15-75-4 BaVD+FeO)	GP	GP	GP
F12 (30-20-75-4 BaVD+FeO)	GP	GP	GP
Fl3 (45-05-75-5 BaVD+FeO)	GP	GP	GP
F14 (40-10-75-5 BaVD+FeO)	GP	GP	GP
F15 (35-15-75-5 BaVD+FeO)	GP	GP	GP
F16 (30-20-75-5 BaVD+FeO)	GP	GP	GP

Legend: F--Fritted
GP—Gloss point

Texture. All the formulations with iron oxide yielded smooth tile samples (Table 9).

Color. Three colors emerged from the trials using the formulations with iron oxide, namely: brown, spumako camel, and chocolate brown (Table 10). Majority of the formulations (F8 to F16) produced chocolate brown tile samples; Formulations FI to F4 yielded brown test pieces; and Formulations F5 to F7 produced spumako camel tile samples.

Characteristics of the Samples Glazed With Formulations Having Manganese Dioxide

Appearance. The tile samples glazed with formulations of banana ash, *Vigan* clay, and DT24 with manganese dioxide were rated GP or gloss point (Table 11).

Table 9. 'Textureoftile samplesglazedwith 16 formulationsofbanana ash, Vigan **clay,and** DTawith iron oxide.

FORMULATION	CHARACTERISTIC		
	SAMPLE1	SAMPLE2	SAMPLE3
Fl (45-05-75-2 BaVD+FeO)	S	S	S
F2 (40-10-75-2 BaVD+FeO)	S	S	S
F3 (35-15-75-2 BaVD+FeO),	S	S	S
F4 (30-20-75-2 BaVD+FeO)	S	S	S
FS (45-05-74-3 BaVD+FeO)	S	S	S
F6 (40-10-75-3 BaVD+FeO)	S	S	S
F7 (35-15-75-3 BaVD+FO)	S	S	S
F8 (30-20-75-3 BaVD+FeO)	S	S	S
F9 (45-05-75-4 BaVD+FeO)	S	S	S
FlO (40-10-75-4BaVDtFeO)	S	S	S
Fl I (35-15-75-4 BaVD+FeO)	S	S	S
F12 (30-20-75-4 BaVD+eO)	S	S	S
F13 (45-05-75-5 BaVDtFeO)	S	S	S
FI4 (40-10-75-5 BaVD+FeO)	S	S	S
FIS (35-15-75-5 BaVDtFeO)	S	S	S
F16 (30-20-75-5 BaVD+FeO)	S	S	S

Legend: S – Smooth

Table 10. Color of tile samplesglazed with 16 formulations of banana ash, Vigan cay, and DT,a with iron oxide.

FORMULATION	CHARACTERISTIC		
	SAMPLE1	SAMPLE2	SAMPLE3
Fl (45-05-75-2 BaVD+-FeO)	B	B	B
F2 (40-10-75-2 BaVD+FeO)	B	B	B
F3 (35-15-75-2 BaVDtFeO)	B	B	B
F4 (30-20-75-2 BaVD+FeO)	B	B	B
F5 (45-05-74-3 BaVD+FO)	SC	SC	SC
F6 (40-10-75-3 BaVD+FeO)	SC	SC	SC
F7 (35-15-75-3 BaVD+FeO)	SC	SC	SC
F8 (30-20-75-3 BaVD+FeO)	ChB	CbB	ChB
F9 (45-05-75-4BaVD+-FeO)	ChB	ChB	ChB
FIO (40-10-75-4BaVD+-FeO)	ChB	ChB	ChB
Fl1 (35-15-75-4 BaVD+-FeO)	ChB	ChB	ChB
F12 (30-20-75-4 BaVD+FeO)	ChB	ChB	ChB
F13 (45-05-75-5 BaVD+FeO)	ChB	ChB	ChB
F14 (40-10-75-5 BaVD+FeO)	ChB	ChB	ChB
F15 (35-15-75-5 BaVD+FeO)	ChB	ChB	ChB
Fl6 (30-20-75-5BaVD+-FeO)	ChB	ChB	CB

Legend: B – Brown
SC --- Spumako camel
ChB – Chocolate brown

Table 1l. **Appearance of tile samples glazed with** 16 formulations of **banana ash,** Vigan cday, and DT,a with **manganese oxide.**

FORMULATION	CHARACTERISTIC		
	SAMPLE1	**SAMPLE2**	**SAMPLE3**
MI (45-05-75-2 BaVD+MnO3)	GP	GP	GP
M2 (40-10-75-2 BaVD+Mn.O3)	GP	GP	GP
M3 (35-15-75-2BaVD+MnO.)	GP	GP	GP
M4 30-20-75-2 BaVD+MnO.)	GP	GP	GP
M5 (45-05-74-3 BaVD+MnO.)	GP	GP	GP
M6 (40-10-75-3 BaVD+MnO.)	GP	GP	GP
M7 (35-15-75-3 BaVD+MnO.)	GP	GP	GP
M8 (30-20-75-3 BaVD+MnO.)	GP	GP	GP
M9 (4505-75-4BaVD+MnO>)	GP	GP	GP
MIO (40-10-75-4BaVD+nO>)	GP	GP	GP
MI (35-15-74 BaVD+MnO.)	GP	GP	GP
MI2 (30-20-75-4 BaVD+MnO.)	GP	GP	GP
MI3 (45-05-75-5 BaVD+MnO.)	GP	GP	GP
MI4 (40-10-75-5 BaVD+MnO,)	GP	GP	GP
MI5 (35-15-75-5BaVDHnO.)	GP	GP	GP
MI6 (30-20-75-5 BaVD+MnO.)	GP	GP	GP

Legend: F – Fitted GP – Gloss point

Texture. All the test pieces glazed with Formulations MI to M16 were smooth tile samples (fable 12).

Table 12. Texture of tile samples glazed with 16 formulations of banana ash, Vigan clay, and DT;a with manganese oxide.

FORMULATION	CHARACTERISTIC		
	SAMPLE I	**SAMPLE2**	**SAMPLE3**
MI (4505-75-2BaVD+MnO,)	S	S	S
M2. (40-10-75-2 BaVD+MO3)	S	S	S
M3 35-15-75-2BaVD+MnO.)	S	S	S
M4 (30-20-75-2 BaVD+MnO,)	S	S	S
MS (45-05-74-3 BaVD+MnO.)	S	S	S
M6 (40-10-75-3 BaVD+MnO,)	S	S	S
M7 35-15-75-3BaVD+MnO.)	S	S	S
M8 30-20-75-3 BaVD+MnO3)	S	S	S
M9 (45-05-75-4BaVD+MnO3)	S	S	S
MIO (40-10-74 BaVD+MnO,)	S	S	S
MII 35-15-75-4BaVD+MO)	S	S	S
MI2 (30-20-75-4 BaVD+MnO3)	S	S	S
MI3 (45-05-75-5 BaVD+MnO3)	S	S	S
MI4 (40-10-75-5 BaVD+MnO3)	S	S	S
MI5 35-15-75-5 BaVD+MO.)	S	S	S
M16 30-20-75-5 BaVD+MO,)	S	S	S

Legend: S–Smooth

Color. Table 13 shows that almost all the formulations with manganese dioxide yielded cypress brown tile samples. Only Formulation M16 (30-20-75-5 BaVD+MnO,) produced spumako camel tiles.

Table 13. Color of tile samples glazed with 16 formulations of **banana ash,** Vigan clay, and DT, **with manganese oxide.**

FORMULATION	CHARACTERISTIC		
	SAMPLE1	SAMPLE2	SAMPLE3
MI (45-05-75-2 BaVD+MnO.)	CB	CB	CB
M2 (40-10-75-2 BaVD+MnO.)	CB	CB	CB
M3 (35-15-75-2 BaVD+MnO)	CB	CB	CB
M4 (30-20-75-2 BaVD+MnO)	CB	CB	CB
M5 (45-05-74-3 BaVD+MnO,)	CB	CB	CB
M6 (40-10-75-3 BaVD+MnO,)	CB	CB	CB
M7 (35-15-75-3 BaVD+MnO,)	CB	CB	CB
M8 (30-20-75-3 BaVD+MnO,)	CB	CB	CB
M9 (45-05-75-4 BaVD+MnO3)	CB	CB	CB
M10 (40-10-75-4 BaVD+MnO.)	CB	CB	CB
M11 (35-15-75-4 BaVD+MnO.)	CB	CB	CB
M12 (30-20-75-4 BaVD+MnO.)	CB	CB	CB
M13 (45-05-75-5 BaVD+MnO,)	CB	CB	CB
MI4 (40-10-75-5 BaVD+MnO,)	CB	CB	CB
MI5 (35-15-75-5 BaVD+MnO.)	CB	CB	CB
M16 (30-20-75-5 BaVD+MnO.)	SC	SC	SC

Legend: CB – Cypress brown
SC --- Spumako camel

Conclusions and Recommendations

Based on the findings of the study, the following conclusions and corresponding recommendations were drawn:

1. Results of the study show that the formulations of banana ash, Vigan clay and DT, with cobalt oxide, except Formulation C15 (35-15-75-5 BaVD + Co0O) produced ffitted tile samples. The glaze on the tests pieces were not able to reach ... melting point at 1020C. The texture of majority of the tests pieces were rated R or rough. It is, therefore, recommended that for tiles glazed with these formulations the temperature should reach 1100C to 1200'C to reach the melting point of the glaze.

2. Among the formulations of banana ash, *Vigan* clay and DT, with iron oxide, only Formulations FI, F2 and F4 yielded tile samples that were rated F or fritted. All the other formulations yielded test pieces that were rated GP or gloss point in appearance. All the test pieces were rated S or smooth in texture. Three colors were produced, namely:. brown, spumako camel, and chocolate brown. It is also recommended that for tiles glazed

with these formulations the temperature should reach 1100C to ensure that the glaze will melt at its melting point

3. All the tile samples glazed with the formulations of banana ash, Vigan clay, and DT3 with manganese dioxide were rated GP or gloss point in their appearance and smooth in texture. Two colors were produced cypress brown and spumako camel.

4. Therefore, it can be concluded that among the different formulations, the mixture of banana ash, Vigan clay, and DT3 with manganese dioxide in all the 16 formulations yield the best glaze for terma cotta vases.

5. In order that UNP Ceramics and Productivity Center will not consume much of electricity in bisquit firing, it is further recommended that a wood-fired kiln be constructed and used in future ceramics research and production activities.

6. Further studies should be conducted relative to this study to improve the quality of ceramics articles.

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