ASSESSMENT OF SOME NIGERIAN CLAYS FOR THE PRODUCTION OF CERAMICS

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Abstract

The need to assess available Nigerian clays for the production of ceramics and to reduce high importation of ceramic wares necessitated this study. Two clay samples were collected; Sample A from Emene in Enugu State while sample B from Ukpo in Anambra State. The clays were prepared for moulding and allowed to age for one week to react with the body so as to get a homogenous mixture. Thereafter, it was used to mould flower vases. The clay samples collected were analysed using X-ray Fluorescence spectrophotometer (X-RF) and Scanning electron microscope (SEM). X-RF result showed that the samples contain different chemical components; Emene clay contains Al_2O_3 (27.63%), CaO (0.83%), Cr_2O_3 (0.10%), Fe_2O_3 (6.01%), K_2O (3.34%) and MgO (2.01%) while Ukpo clay contains Al_2O_3 (31.51%), CaO (0.18%), Cr_2O_3 (0.02%), Fe_2O_3 (0.87%), K_2O (1.83%) and MgO (0.16%). The concentration and weight of the chemicals present in the sample were noted to vary as Ukpo clay tends to have high weight as compared to Emene clay. More so, the SEM result showed the microstructure of the clay samples with more holes and smaller particles. This suggests that the clay is light and more compact, on the other hand, Ukpo clay showed less holes and bigger particles which make it heavy, but with the use of deflocculants, it can be used for the production of ceramics. The results indicated that the two clay samples are good for the production of ceramics due to their chemical and surface morphological properties. Hence, the study recommended that Nigerian clays should be utilized in the production of ceramic wares in order to reduce the importation of these ceramics into Nigeria; thereby creating employments for Nigerian youths, reducing high cost of ceramics and the support of indigenous goods.

Keywords: *Ceramics, Emene clay, Ukpo clay, XRF, SEM.*

1.0 Introduction

Clay minerals have been used as raw materials in many industrial fields for ages due to their physico-chemical properties, abundance and relatively low production cost. Worldwide, clayey materials are the main raw materials used in the production of traditional ceramics. Applications of the clay minerals depend on their compositions, structures and physical properties. Clays undergo a lot of physical and chemical changes which determine predominantly their ceramic properties during firing. The changed physical and chemical properties of the clay minerals with firing temperature determine their uses as an industrial ceramic raw material. For economic reasons, ceramic industry prefers to use clayey materials from nearby deposits. As a consequence, the characterization of ceramic properties of the clay minerals is important for their performance [1].

In ancient times, sources of clays were widely available, between the soils or surface sediments, and have been used as the proper sources for ceramics production without further treatment, due to the natural mixture of plastic and non-plastic components [2]. Ceramics is an inorganic nonmetallic material obtained through thermal processing of natural raw materials at relatively high temperature [3]. The raw materials are clays with finely divided quartz (sand) (0.02–0.04 mm) and feldspar, responsible for the rheology along the thermal processing. Clay is a group of minerals in earth that is granular; plastic, when mixed with a little water; or hard and brittle, if combusted. The clay is composed of hydrated aluminum silicates, with the addition of an appreciable amount of other elements: magnesium, iron, calcium, and potassium [4]. The clays retain fluid water (liquid) (from pores between clay particle aggregates) at low temperature, molecular water from the surface of particles or crystallites at medium temperature, and, sometimes, neutral molecules (H_2O) or ionic hydroxyl groups (OH^-) liberated at higher temperatures during thermal processing [5].

The production of ceramics was first implemented in the Neolithic period. When the Greeks and Romans developed lime mortar cements, with a remarkable resistance, and some of these archaeological sites stand testimony to this day [6]. But with time, industrial revolution in the eighteenth and nineteenth centuries registered significant improvements in the ceramic industry, while the twentieth century contributed to the scientific understanding of these materials. There are two major classes of naturally occurring clay which are primary and secondary clay. Primary clay is known as residual clay. It is rich in alumina and has low percentage of iron oxides and hence low in plasticity. Emene clay falls under this category. Secondary clay which is also known as sedimentary clay produce finer clays and hence are more plastic clay [7]. Ukpo clay falls under this category.

This study is aimed at harnessing the potentials of Nigerian clay as raw material for the production of ceramics.

2.0 Materials and methods

2.1. Sample collection and preparation

The raw materials, Iron (iii) oxide, Quartz, silica, feldspar, e.t.c were surveyed. The samples were collected from the locality of Emene in Enugu State and Ukpo in Anambra State. The clay samples were collected, broken and crushed using a mortar.

They were washed, sieved, dried and kept ready for the ceramics production and analyses.

2.2. Methodology

2.2.1. Production of the ceramic

Two hundred grams of clay samples A (Emene clay) and B (Ukpo clay) were properly weighed respectively. Each of the samples was then soaked in water and allowed to settle then decanted as to remove excess water. At this stage, the clay in its liquid form is poured into it POP (Plaster of Paris) bath. The POP was used to absorb the water in the clay leaving plastic clay. This clay is then covered with water proof; this process is known as ageing. The clay was allowed to age for one week to react with the body, so as to get a homogenous mixture. After this ageing process, the clay was used for the design.

For the flower vase, casting method was used. The sample was deflocculated (this is where clay is mixed with sodium silicate) to give a homogeneous liquid known as 'slip'. This slip is then used for casting, which is the POP mould of different shapes and sizes. After 7days, casting of the mould was formed and came out fully on its own after being separated from the POP. The cast was then allowed to dry. After drying the cast was trimmed in a process known as 'Peddling'. Then again the clay is allowed to dry for a period of 1-2 weeks, then dried in the oven at a temperature of 1200^{o}C. At this temperature, the remaining water in the clay was completely dried off. Then Bisc firing was performed. It is the first stage of firing done at 800^{o}C, then glaze was applied.

Glaze is known as the glossy material applied on the surface of the ceramics which gives the shiny properties of the ceramics. It is made up of a glass medium which is usually silica. The oxides which give the different colours in the glaze are mostly transition element e.g cobalt oxide, tin oxides, iron (III) oxides e.t.c.

After this, the ceramics is fired again at a temperature of 1100^{o}C or 1200^{o}C. This was the final stage of firing known as the Glaze firing. At this temperature, the silica will melt and form the glossy/glassy/shiny surface on the ceramics [8].

2.3 Characterization of clay properties

Clay properties were characterized via scanning electron microscope, SEM and x-ray fluorescence, X-RF analyses.

SEM analysis: The morphological character of the clay was done by weighing 5g of the sample. The 5g was transferred into SEM model840.A11.

X-RF analysis: The quantitative analyses of the major minerals within the clay samples were done by x-ray fluorescence spectroscopy using a magi X-pro model X-RF spectrometer.

3.0 RESULTS AND DISCUSSION

3.1: The results of the X-ray fluorescence analyses are as shown in Table 1.

Table 1: X-Ray Fluorescence(X-RF) of samples A and B

	Chemical Composition	Sample A (wt %)	Sample B (wt %)
1	Al_2O_3	27.63	31.51
2	CaO	0.83	0.18
3	Cr_2O_3	0.10	0.02
4	Fe_2O_3	6.01	0.87
5	K_2O	3.34	1.83
6	MgO	2.01	0.16
7	Na_2O	0.97	0.31
8	P_2O_5	-	0.02
9	SiO_2	42.01	68.00
10	SO_2	-	0.14
11	SrO	-	0.01
12	TiO_2	3.00	0.74
13	ZrO_2	-	0.01

It is observed from the result as shown in Table 1, that in the Emene clay, the percentage weight of Al_2O_3 is 27.63%, CaO is 0.83%, Cr_2O_3 is 0.10%, Fe_2O_3 is 6.01%, and K_2O is 3.34%. The weight of MgO, Na_2O, SiO_2 and TiO_2 in the same Emene clay are 2.01%, 0.97%, 42.01%, and 3.00%, respectively, while P_2O_5, SO_2, SrO and ZrO_2 are all zero respectively. For, Ukpo clay, the percentage weights of the oxides present are; Al_2O_3 is 31.51%, CaO is 0.18%, Cr_2O_3 is 0.02%, Fe_2O_3 is 0.87%, K_2O is-1.83%, MgO is 0.16%, Na_2O is 0.31%, P_2O_5 is 0.02%, SiO_2 is 68.00%, TiO_2 is 0.74% while SrO and ZrO_2 are 0.01% respectively. The absence of some oxides may be due to the geological compositions of the Emene and Ukpo regions. These oxides also have some negative impacts on clay production and environment; so as a result, their absence in the clay samples is a very positive one. Some of the negative effects of these oxides include:

P_2O_5— generates a strongly negative potential and reduces deflocculants power with ageing suspensions.

SO_2— Presence of SO_2 in excess can lead to work hazards e.g nose irritation.

ZrO_2— Possesses high melting point and resist deflocculation.

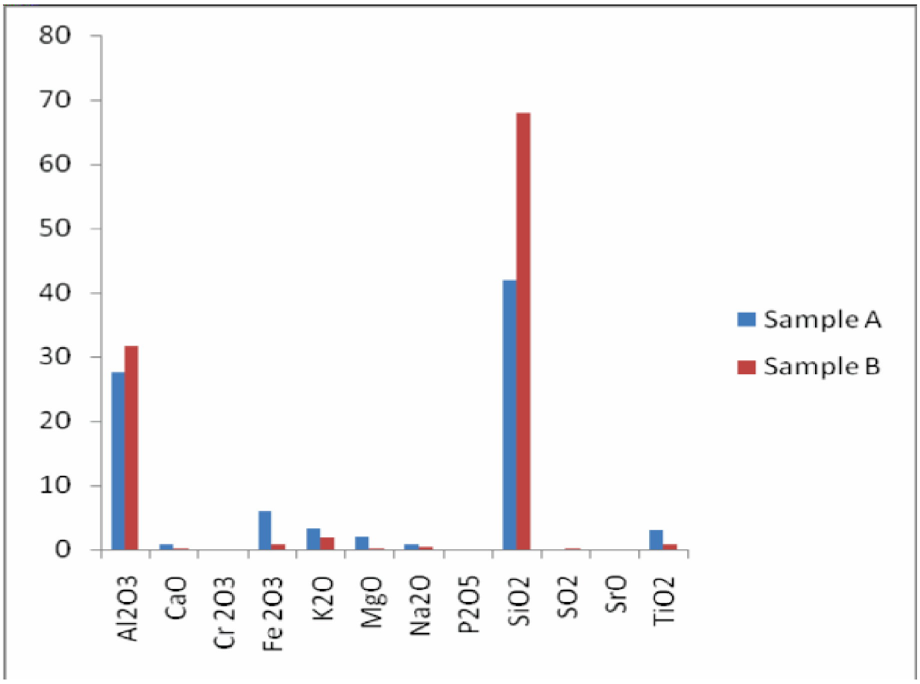

Fig. 1: Comparison of Clay Weight of Sample A and B

Fig. 1 shows that the percentage weight of Al_2O_3 in Ukpo clay is higher than that of Emene clay, which suggests that the presence of high alumina content in Ukpo clay makes it to be of better quality clay for the production of ceramics. The percentage weight of CaO in Emene clay is more than that in Ukpo clay, suggesting that the tensile strength is higher. Cr_2O_3 percentage weight in Ukpo and Emene clay are almost the same weight. The percentage weight of Fe_2O_3 in Emene clay is more than that of Ukpo clay. The percentage weight of K_2O in Emene clay is more than that of Ukpo clay while the percentage weight of SiO_2 in Ukpo clay is higher than that of Emene clay as shown in Fig.1.

3.2: The result of the Scanning electron microscope

The result of the SEM micrographs of the clay samples A and B are shown in Fig.2.

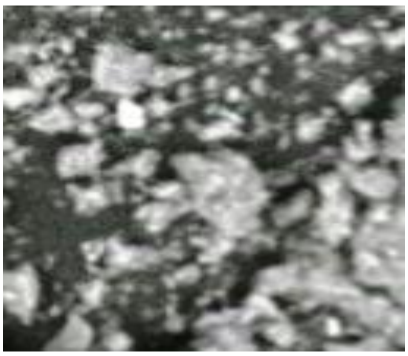

Fig.2a: SEM micrograph of Sample A

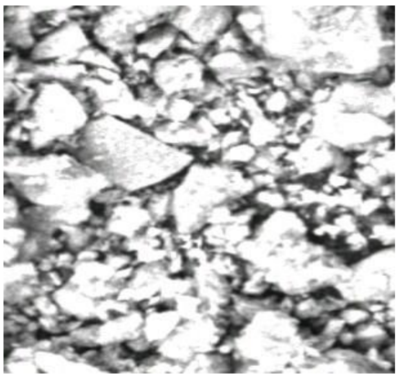

Fig.2b: SEM micrograph of Sample B

The micrographs show the morphological properties of sample A, (Emene clay) and sample B, (Ukpo clay). It is seen from Fig.2a, that the microstructure of the clay sample A shows more holes and the particles are smaller. It suggests that the clay is light and more compact. This shows that it can be very useful in the production of ceramics. Fig.2b shows less holes and bigger particles which make it heavy. But with the use of deflocculants, it can be used for the production of ceramics [9, 10].

4.0 Conclusion

The study indicates that the chemical composition of clay soil used for the production of ceramic varies in their concentration and weight. Most of the oxide concentrations in Ukpo clay are found to be higher than that in the Emene clay. This may be due to the fact that the samples were collected from different location which thus implies that location affects the compositional concentration and weight of clay chemical composition. The chemical properties of the clay give the produced ceramic its characteristics and its perfectness depend upon the right proportion of tempering material, preparation of clay, thickness of the products (eg. flower vase, plates etc), beating, etc. If these are not flawlessly made, then the flower vase produced might develop crack or be totally damaged at the time of firing.

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