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CHEMICAL CHARACTERIZATION OF CLAY IN OVIA LOCAL GOVERNMENT AREA OF EDO STATE, SOUTH-SOUTH REGION OF NIGERIA

¹Iroque W.A, ²Orumwunse F.F. O and ³Sadjere, E.G

^{1,2,3}Department of Mechanical Engineering, University of Benin, Edo State, Nigeria

¹wilfred.iroque@uniben.edu, ²friday.orumwunse@uniben.edu, ³godwin.sadjere@uniben.edu

Abstract

An experimental and analytical study was carried out in order to investigate and characterize ovia clay deposit of river ovia in ovia local government area of Edo state, Nigeria. Nigeria has abundance of clay deposit which is highly required for various industrial uses, however findings have revealed that they may be inappropriately or under-utilized arising from the lack of knowledge of their chemical behavior. This research was aimed at exploring the chemical characterization of the ovia clay with a view to ascertain its suitability for various industrial uses. The clay was therefore extracted and prepared for chemical analysis with no significant beneficiation in order to understand its natural composition and their possible effects in its service performance. Result from the experimental procedures showed that the ovia clay belongs to the alumina-silicate light colored bentonite containing montmorillonite. There was significant contents AlO (>25%) SiO (>45%), FeO (3.1%) NaO (4.1%), MnO (1.05%), KO (1.9%) and MgO (5.1%). It is concluded that the ovia clay can serve various purposes including for use as refractory fire clay, pharmaceuticals etc.

Key words: Analysis, Beneficiation, Chemical, Ovia, Clay

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1.0 Introduction

Clay deposit is one of the natural earth composite materials found in abundance in many parts of Nigeria. It is a product of the geological and chemical weathering of feldspathic rock which can occur in top surface and or from volcanic ash in water bodies. The clay deposit in Nigeria is a significant source of raw material for the ceramic, pottery, foundry, building, textile, oil and gas industries amongst others. The viability and suitability of clay for various uses are partly dependent on its chemical characteristics with a link to its mode of formation. Investigations by researchers have often reported the natural clay composite to contain high composition ratios of alumina (Al_2O_3) and silica (SiO_2) amongst other trace elements which are though referred as impurities but play significant roles in its physio-chemical behavior and transformations. The chemical composition of clays has been used for the basic classification of refractories. ASTM (2013). Different clays have been observed to have varying chemical composition in amount and consequently varying suitability for different purposes. This is clearly supported by Abuh et al (2014) who asserted that the various clays sourced from different regions in Nigeria have shown varying compositions in their physio-chemical analysis and hence respond differently to different thermo-physio-chemical conditions which they usually undergo while being transformed. It therefore means that an understanding of the formation, composition and characteristics of clays is significant in its characterization and use. However; there are still host of clay deposits in various parts of Nigeria yet to be intensively explored and one of such clay deposit is the ovia river clay deposit in Edo state of Nigeria.

Ajala and Badarulzaman, (2016) evaluated the chemical properties of Aloji fire clay bricks. Their aim was to investigate its suitability for the production of refractory fireclay brick used as furnace lining. In their findings the chemical (oxide) composition of Aloji clay was Al_2O_3 38.8%, SiO_2 57.8%, Fe_2O_3 0.54%, TiO_2 1.61%, MgO 0.28%, K_2O 0.23%, P_2O_5 0.25%, SO_3 0.02%. From the oxides in the X – Ray Fluorescence Spectroscopy (XRF) result, the dominant oxides were SiO_2 and Al_2O_3 with weight values of 57.8 % and 38.8 % respectively which made the authors to conclude that the clay belonged to alumino-silicate group suitable for production of fireclay bricks.

Ochieze and Esezobor, (2018) carried out research on performance evaluation of refractory bricks produced from Osiele and Ikorodu clays blended with zircon. The chemical compositions of the raw materials were determined using the Atomic Absorption Spectrophotometer (AAS-PG990AFG) and the results showed that the Osiele clay had a composition of Al_2O_3 30.31%, SiO_2 51.73%, Fe_2O_3 1.46%, CaO 0.16%, TiO_2 0.07%, MgO 0.28%, K_2O 2.31%, LOI 13.08%, Na_2O 0.62% while the Ikorodu clay had a chemical composition in percentage as follows; Al_2O_3 37.10%, SiO_2 41.56%, Fe_2O_3 0.10%, CaO 0.92%, MgO 1.32%, K_2O 0.12%, LOI 18.78%. Their results showed that the clay samples belonged to the family of alumino-silicate and semi-acid refractory since the alumina value fell within the classification of the categorization range of 25-45% (Gupta, 2008). The authors asserted that the presence of impurities in alumino-silicate refractory such as, Fe_2O_3 , K_2O , MgO , lowers the refractoriness and service limit of the bricks. The apparent porosity of the refractory bricks produced from clay samples with no zircon additive which are 15.27% and 16.11% respectively fell below the standard value of 20 – 30 according to Chesti (1986) while their bulk densities

of 2.20 and 2.36 g/cm³ respectively fell within the standard range of 2.2 – 2.8 g/cm³ indicating the presence of few pores in the refractory bricks

Etukudoh et al (2016) carried out research on the characterization of Ezzodo clay deposit in Enugu state for its industrial potentials. The chemical analysis of the clay showed silica (61.83%) and alumina (16.43%) as the major constituents while other metal oxides such as Fe₂O₃ (6.48%), CaO (1.85%), K₂O (2.26%) and Na₂O (1.31%) were present in appreciable amounts. The findings of their work revealed that Ezzodo clay had good industrial potentials and could be used in the manufacture of ceramics, high melting clays, refractory, bricks, tiles and color vase but required additives to help obtain the desired properties.

The ceramic industry and many other industries which utilize clay as a raw material in Nigeria are reported to use about 70% of all clays marketed in crude, beneficiated and finished products forms making the clay related industry a huge market where in about five billion naira is spent annually in the importation of ceramic products made from clay. Abuh et al, (2014). Relying on imported raw materials of clay plays down efforts aimed at promoting the country's local content and indigenous manufacturing. It also results in loss of internally generated revenue and unemployment. In view of these, the Federal Government of Nigeria had in 2003 restricted the importation of foreign clays with a view to tapping into the vast deposits of the raw material (Oriji et al., 2014).

Iroque et al (2021) investigated the viability of Ovia River clay for the production of refractory bricks and the suitability of such bricks for use in heat treatment furnace with operational temperature range of 800 °C to 1000 °C. Critical characteristics such as thermal and mechanical characteristics of the Ovia clay bricks which were significant in service were investigated. Results showed that; the test bricks had bulk densities between 1% and 1.8%. The minimum and maximum values for apparent porosity were 9% and 21% respectively, while loss on ignition were 1.4% and 11.8%. Maximum Cold crushing strength was 150kg/cm² at firing temperature of 1200 °C, Shrinkage test of the bricks showed minimum value of 1.9% and maximum value of 4.8%. The slag attack resistance of the bricks was very good, the thermal shock resistance under high temperature of over 1400 °C and 10 cycles met the ASTM recommended 10 cycles for good refractory bricks. Studies have been carried out extensively to understand the formation, composition, characteristics and properties of different clays in various part of Nigeria. the outcome of such studies has gainfully helped in the categorization of many clay deposits, their suitability for use in various semi-finished and finished products. However; there is still a lack of documented articles, publication or records which have intensively dwell on many clay deposits found in the vast regions of Nigeria. In view of this, the present study was focused on exploring the Ovia clay with the aim of establishing its chemical composition and how it might contribute to its material behavior.

2.0 Materials and Methods

2.1 Sample sourcing

Some quantity of the clay was extracted directly from the river site in Ovia North East local Government of Edo state, Nigeria. The sample was sun dried using natural open air to remove moisture and the resulting large lumps were hammered to smaller sized lumps that was later pulverized into fine powder with a pulverizing machine. The sample was further dried in

batches of well spread out bulk materials for larger surface area in an oven at temperature of 90°C for 3 hours after which it was removed and cool down in open air for total removal of moisture. For an extensive investigation of the sample, other aggregates materials needed such sand, water were also acquired for the preparation of samples of composites. Other materials and experimental components that were required and sourced for experimentations were Atomic Absorption Spectrometer (AAS) machine and pyrometer, hand trowel, mortar and pestle, sieves, heat furnace, electric digital balance and hydraulic press machine.

2.2 Sample preparation and testing

The chemical analysis of the clay was carried out with an Atomic Absorption Spectrometric (AAS) machine. The AAS technique was used to identify and determine the concentrations of elements present in the samples in weight/per kilogram and per liter. Five grams of the already ground and sieved fine powdered (about 50µm particle size) sample of the bulk material was separately mixed with 20-ml of 0.1N HCl extracting solution in a 300-ml beaker and placed in a mechanical shaker for 15 minutes. The mixture was filtered through Whatman #42 filter paper into a 50-ml volumetric flask and diluted to 50 ml with the extracting solution. The test specimen was then placed in the AAS in order to determine the elements present in the sample. The procedure was repeated for the sand and refractory castable. The test samples were individually run using the prepared programs (calibrations) and the concentrations of each element present in the samples were calculated and displayed.

The chemical composition of Ovia clay has effects on its behavior under specific conditions. Iroque et al, (2021) had reported the mechanical properties of Ovia clay shown in Table 2.1 which they alluded to its chemical composition.

Table 2.1 Physio-Mechanical Properties of Ovia clay as reported by Iroque et al, (2021)

| Property | Value |
|---|-------|
| Apparent porosity (%) | 21.66 |
| Bulk density (g/cm ³) | 1.33 |
| Cold crushing strength (g/cm ²) | 1.48 |
| Loss on Ignition (%) | 8.12 |
| Shrinkage (%) | 4.76 |

3.0 Results and Discussion

Following the chemical test analysis carried on the ovia clay using the AAS machine, the result obtained is as shown in Table 3.1.

Table 3.1 Chemical composition (wt %) of samples of clay

| Samples | Composition | | | | | | | | | | | | |
|-----------|-------------------------|---------------------------------------|------------|---------------------------------------|---------------------------------------|------------|------------|--------------------------|-------------------------|------------|------------|------------|------------|
| | SiO ₂ (%) | Al ₂ O ₃ (%) | ZnO (%) | Cr ₂ O ₂ (%) | Fe ₂ O ₃ (%) | MnO (%) | MgO (%) | Na ₂ O (%) | K ₂ O (%) | CaO (%) | CuO (%) | PbO (%) | NiO (%) |
| Ovia Clay | 54.92 | 26 | 0.65 | 0.90 | 3.1 | 1.05 | 5.10 | 4.10 | 1.90 | 0.60 | 0.28 | 0.00 | 0.71 |

From the chemical and physical analysis of the clay bulk materials and clay bricks, result data obtained was tabulated as shown in Table 3.2. The tabulated result allowed for ease of comparison with reported or convention standard data that may be significant in characterizing the Ovia clay.

Table 3.2 Chemical properties of Ovia clay

| Characterization/property | Magnitude/ 60c/40s and 70c/30s | Remark | Recommended standard |
|---------------------------|--|---|---|
| Chemical composition | Significant: silicate 55%, alumina 26%, ferric oxide 3.1% MnO 1.05%, MgO 5.1%, Na ₂ O, 4.1% and K ₂ O 1.9% | Belong to; alumina-silicate monolithic group. Can be used as refractory based on its high silica content and aluminate content. | Alumina silicate group; alumina content of between 25% and 45%. |
| Color | cream colored unprocessed, reddish brown on high temperature (1200 ⁰ C) treatment | Suspected bentonite | Volcanic ash formation, light colored, swells on hydration |

From the Tables 2.1, 3.1 and 3.2 it could be inferred that the ovia clay belong to the alumina silicate group characterized by the major oxide composition of silica and alumina oxide. It also belongs to the monolithic group with a characteristic light color typical of bentonites. The ovia clay may be classified as material for refractory due to its silica and alumina contents as well as temperature range for sintering and vitrification. Silica contents for ceramics (>60.5%), for refractory bricks (>51.7%) and for high melting clays (53-73%) while Alumina content for; ceramics (>26.5%), Refractory bricks (25-44%), paper (33.5-36.1%), paint (37.9-38.4%). Chester, (1973). The clay being a refractory material indicates having those chemical and physical properties that makes it applicable for structures or as components of systems that are exposed to environments above 1000 °F (800K, 500 °C). Saradava (2014), Bhatia (2011). The presence of impurities in alumino-silicate refractory such as the refractory oxide comprising Fe₂O₃, MgO, K₂O and other metal oxides lowers the refractoriness and service capacity of the bricks.

4.0 Conclusion

The result of the chemical analysis of Ovia clay proved that the Ovia clay sourced from River Ovia in Edo state has a potential for industrial use in ceramics, oil drilling, bricks production etc. Test bricks produced from the Ovia clay exhibited significant properties that made them suitable for use as high density refractory bricks for high temperature furnace lining such as heat treatment furnace and incinerators. The relative mix of alumina and silica in the clay indicates their suitable for diverse use in thermal facilities considering the temperature capacities which exceeds service temperatures of many thermal facilities which include heat

treatment furnace, incinerators which operates at between 300 and 1000⁰C. The understanding of the chemical properties of the bricks made from Ovia clay as investigate in this work reveals a lot about the clay which before now had limited research documentations about its chemical properties.

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