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Characterization of Clay Deposit in Nkisi River of Onitsha North LGA, Anambra State Nigeria

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Abstract: A combination of analytical techniques such as AAS and XRD were employed to characterize clay deposit in Nkisi river Onitsha North LGA, Anambra State. The sample was also subjected to pysico-chemical test. The results obtained show that silica (SiO_2) content was the highest, followed by alumina (Al_2O_3) content, while the alkali and alkaline earth metal are in trace amount. XRD (X-ray diffraction) results of the deposits analyzed with Bragg's Wolff equation, and international center for diffraction data software have identified the samples to contain the phylliosilicate minerals of mica group identified as Prehnite ($CaAl_2[SiO_3]O_{10}[OH]_2$). The physico -chemical analysis of the deposits corresponds with the XRD results.

Key words: Clay, deposits, X-ray diffraction, analysis, silica, phylliosilicate.

1. Introduction

Apart from petroleum, gas and coal resources, the exploration, mining and exploitation of Nigeria mineral resources have not received sufficient attention [1]. Delving into geological survey of Nigeria soil, it was reported that clay as one of the major Nigeria minerals deposits cover an estimated proven reserves of billions of tones, and these days mineral are discovered all over the states in the country [2]. Clay a fine textured earth that is plastic when wet but hard and compact when dry or a term used to refer to the finest grain particles in a sediment, soil, or rock [3], which occur both in the plain and river rime areas [4]. One of the best-known applications of clay is in the manufacture of such articles as pottery. Another major application of kaolinite is in the paper industry where it may be used either as filler or for coating paper. The metallurgical industry employs clay mixed with sand to form moulds that are used for casting operation. In the oil industry, clays are used in the drilling of oil wells and also as important constituent of catalyst for refining petroleum and also in the separation of gasoline, gas and coke [1]. A lot of project research has been carried out about the conversion of clays for industrial uses. The percentage of minerals oxide (Fe_2O_3, MgO, CaO, Na_2O et al.) in the clay ultimately determines the area of application of the clay such as in bricks, floor, tiles, paper, et al., while the quantity of the alkali metal oxides (Na_2O, K_2O, CaO et al.) indicates their suitability for making ceramic product and other refractory materials [5]. A material is refractory in nature if it has a very high melting point in addition to its physical, chemical, mechanical and thermal properties that make it suitable for use in furnaces, kilns, reactors and other high temperature vessels [6].

Nigeria has appreciable distribution of industries engage in metal and process industries hence the need for raw materials to support their growth. Clay products such as ceramics wares, bricks, roofing and floor tiles are cheaper and durable building materials than cement especially under tropical conditions [5].

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They should therefore be utilized to reduce over dependency on cement particularly in Nigeria.

Ironically despite the vast deposits of clay across every region in Nigeria, though their properties differ from site to site on account of geological differences, the bulk of clay requirement of the nation is imported from the United Kingdom, USA and Japan [3]. The present economic state imposes the need for internal sourcing of raw materials to meet up increasing demands.

In this study the main goal is to characterize the clay deposits in Nkisi River, Anambara State of Nigeria so as to estimate its utilization as industrial raw material for ceramics and enamel wares.

2. Experiments

The sand sample was collected randomly from Nkisi River, Onitsha North LGA, Ananmbra State, Nigeria. The sample was dried and pulverized. Physical, chemical and mineralogical characterization was done. The particle size of the sample was determined using electo-magnetic sieve shaker (Cisa Cedaceria Ind Model BA 200N) with sieve of mesh sizes 500 μm, 355 μm and 250 μm respectively. The specific gravity and density were determined gravimetrically. The colour was also compared with standards. Elements: Si, Al, Fe, Ca, Mg, Mn, K, Na, Ti, Fe, composition were determined after acid digestion using Buch Scientific 210 VGP. LOI (loss on ignition) was done by gravimetry method.

The mineralogical characterization was done using monochromatic X-ray (MD 10 mini diffractometer, version 2) with beta filter CuKα radiation wavelength of 1.5406 Aº and automated silt. A set of 2θ angle ranging from 15º-75º were used, this was done at Engineering Material Development Institute Akure, Ondo State, Nigeria. In the X-ray absorption analysis, as the sample was exposed to a beam of X-ray of suitable energy, diffraction occurred. The angles of deviation and relative intensities of the deviated beams were measured and used for the structural properties determination. The following structural parameters were determined; crystal system, crystal structure, inter planar distance and lattice constant.

3. Results and Discussion

3.1 Physical Characterization

From the result shown in Table 1, the particle size shows high parentage clay followed by sand then silt. This shows that the sample is less porous thereby increasing its refractoriness. The presence of pores in clay affects its strength by reducing the cross sectional area to an applied load [8]. The high percentage of clay is an indication that they will be of geological, industrial and agricultural importance [9, 10].

3.2 Elemental Composition

The elemental composition (in their oxides) of Nkisi River deposit is shown in Table 2. The result shows high silica and alumina content of ratio 2:1 while the alkali and alkaline earth metal oxides are observed in low percentage.

The degree of verification and refractoriness increases with increase in alumina content, while the

Table 1 Physical characterization of sand sample.

Particle size distribution	A
(PSD) [7] (5)	(%)
Clay	67
Sand	21
Silt	32
Colour	Gray
Specific gravity	1.245
Density （gcc^{-3}）	1.232

Table 2 Chemical composition of sample.

Component	Wt. (%)
SiO_2	41.67
Al_2O_3	27.02
Fe_2O_3	0.30
TiO_2	0.07
MgO	-
MnO	0.06
CaO	0.02
K_2O	5.00
Na_2O	0.05
*LOI	10
pH	4.8

*LOI: Loss on ignition.

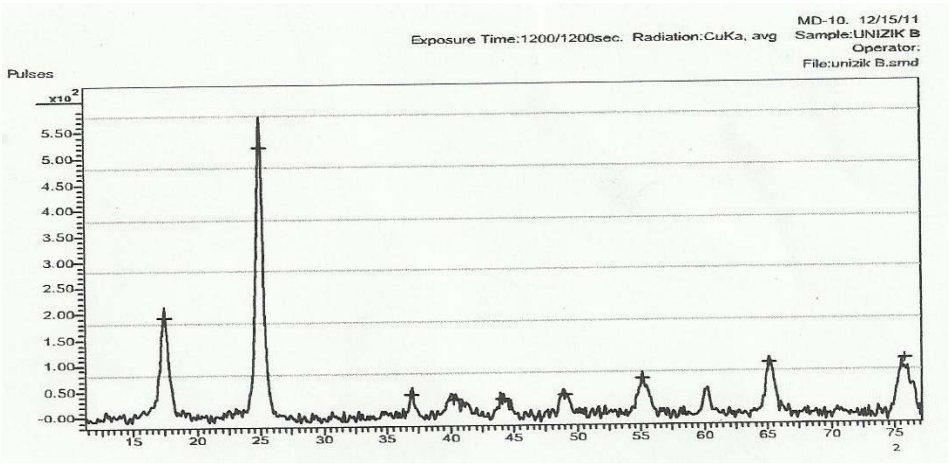
presence of alkali and alkaline earth metal oxide in low concentration in the sample, lowers its fusion temperature and also accounts for relatively high refractoriness [11, 12]. This also favours very low thermal expansion and high resistance to sudden change in temperature [13]. For good refractory characteristics clay should have percentage silica and alumina content between 50% and 30% and small amount of Fe_2O_3, TiO_2 and CaO [14]. This shows that the sample falls into clays recommended for refractory work.

The sample shows low porosity because of its high clay content relative to low weight LOI, which implies that it consists of low amount of combustible materials. Hence, an added advantage for its application in ceramics and enamel industries.

3.3 X-ray Diffraction Investigation

The results of XRD (the X-ray diffraction) reveal that the sample comprised of different types of minerals with phyllosilicates of mica group and feldspar predominant in the sample. In Figs. 1 and 2 are shown the XRD spectra and interpretation of the sample.

The sample is identified as phrenite of formula $CaAl_2(Si_3)O_{10}(OH)_2$ in Fig. 2.



	2	d	I int	I max	I rel	I corr	FWHM
	17.39	5.09951	8827	192.9	43.2	54.2	0.80722
	24.91	3.57374	20410	520.1	100.0	100.0	0.6922
	36.84	2.43943	1532	40.7	7.5	6.5	0.56057
	40.22	2.24225	2217	30.8	10.9	9.3	1.322
	44.06	2.05503	1362	31.0	6.7	5.6	0.91932
	48.91	1.86233	1365	37.6	6.7	5.5	0.7824
	55.10	1.66676	3583	67.9	17.6	14.1	0.96928
	65.12	1.43246	4527	95.9	22.2	17.5	0.83289
	75.74	1.25575	6653	101.6	32.6	25.4	1.1551

Fig. 1 X-ray diffraction of the sample on CuKα; in the 2θ region, glancing angle 15°-75°.

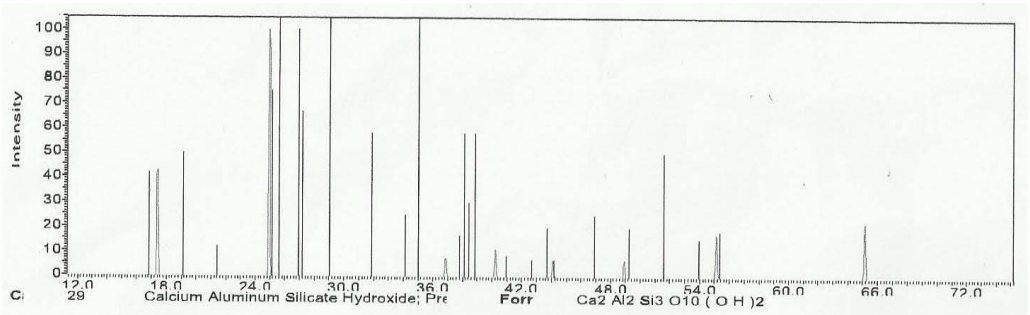


Fig. 2 XRD interpretation of the sample.

Table 3 Structural parameters of sample A.

Empirical formula	$CaAl_2(Si_3)O_{10}(OH)_2$
Wavelength (Å)	1.5405
Crystal system	Orthorhombic pyramidal
Crystal size (mm^3)	0.113
Space group	P2/cm
a (Å)	5.09951
b (Å)	9.37 (1)
c (Å)	10.23 (9)
β (°)	99 (7)
Volume, V ($Å^3$)	512.19
Z	2
2θ range(°)	15-75

The basal (001) *d* spacing of the Bragg's wolf equation ($n\lambda = 2d\sin\theta$) of the sample gave an orthorhombic pyramidal crystal structure of class space group P2/cm which was sharp at 5.09951 Aº during the heating process at the corresponding glancing angles of analysis.

The chemical composition shown in Table 2 compared well with the mineralogical composition. Prehnite is a tetrahedral brittle mica named after Dutch Colonel, H. Von Prehn. From the result of the X-ray characterization in Table 3, the lattice constant of 5.09951, colourless and cleavage at (001) compared well with a research report of a = 5.47 Aº, colourless and (001) cleavage [15].

4. Conclusions

In this study, clay deposits from Nkisi River have been characterized for their application in ceramics and enamel industries. The mineralogy is dominated with phyllosilicate mineral of mica group. The chemical composition of the clay mineral were analysed shows that it contains high value of quatz (SiO_2), which is the major component of mica and feldspar and this places them as a good refractory material. Also high percentage aluminum oxide confirms why this clay can be used for paint, cosmetics and paper manufacture. The level of alkali and alkaline earth metal oxides are an advantage to the desired application in ceramics and enamel industries. Most developing nations that are consumers of refractory materials, like Nigeria, have to send their hard earned foreign currencies on importation of these materials to meet their needs [16, 17]. In southern part of Nigeria most regions are blessed with natural resource like clay which occurs both in plains and river rime areas [4]. This study has implied that these local raw materials should be used in place of the imported ones.

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