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Comparative Analysis of Thermal Properties of Selected Clay Samples

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Abstract: *Clay plays a predominant role in human life and their value is recognized in many economic branches, agriculture, civil engineering and environmental studies. This research is aimed at carrying out a comparative analysis of the thermal properties of selected clay samples. The clay samples were coded A and B, Obtained from Birnin Kebbi and Maiyama local Govt. Areas of Kebbi state. Nigeria. The thermal properties of the selected samples were determined using standard ASTM Techniques which includes TGA, DTA and XRD techniques. The results of the research shows that both samples contained Halloysite, kaolinite and calcium carbonate. Sample B has the highest amount of kaolinite clay with the value of 3.676 and it is therefore the best for industrial applications, more especially in the areas of pottery and ceramic production, paper production and modern pop.*

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I. Introduction

Clays are natural materials abundantly found and largely used by the prehistoric civilization to make household utilities. Presently, they are still used in the manufacturing of ceramic products such as bricks, porcelain, sanitary ware, floor, roofing tiles and also used in various industrial applications. As a basis of traditional and modern ceramic fabrication, raw material selection plays a vital role in the final product design. The final product is strongly influenced by chemical and mineralogical compositions and particle size distributions (Kitouni and Harabi, 2011).

Therefore, the knowledge of above mentioned properties of the natural clay materials is of great interest since it provides useful information in the selection of more appropriate clay raw materials associated with industrial applications. Generally, clays contain different non-clay minerals as impurities besides major and minor clay minerals (Sousa and Holanda, 2011). Clay is an unconsolidated rock matter, with very fine grain which is plastic when wet and undergoes ceramic change to become hard and stony when heated. The ceramic industries are the major users of clay. These industries consume about 70% of all clays marketed in crude or beneficiated form and those marketed only as finished products (Fakolujo et al., 2012). Clay is composed of silica (SiO_2), Alumina (Al_2O_3) and water (H_2O) plus appreciable concentration of oxides of iron, alkali and alkaline earth, and contains groups of crystalline substances known as clay minerals such as quartz, feldspar, and mica. These other minor oxides components (impurities) which occur in variable quantities are important as their presence impart some properties to clay which are of technical value. It is important to note that the amount of impurities allowable in clay depends on the purpose for example; when white wares are needed, coloring impurities such as Fe_2O_3 must not use (Abia-Bassey et al., 2006)

II. Materials And Methods

2.1 Materials

The materials used in this research include;

Hoe; -This is simple Farm tool with metal bled on its head place on a wooden handed. Use for digging a clay sample.

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Plate 1; *Hoe*

Plate 2 *plastic bottle*

Plastic bottle; - this are small plastic container, look like a beaker with plastic cover. Use for storage of sample. Grinding Mortar and Pestle; - those are simple local machine used for grindings the clay sample and resizing of the grain.

Plate 3; *Grinding mortar*

Plate 4; *Pestle*

plate 5; Mesh

Mesh; - A structure made of connected strands of metal, fiber or other flexible/ductile material, with evenly spaced openings between them. Use for sieving the clay sample.

Samples: - Two different clay samples used for this research were collected from Birnin kebbi and Maiyama local government. In Birnin kebbi local Govt. Sample was collected from Birnin kebbi fadama area, in Maiyama local Govt. the sample was collected from Mungadi fadama area of kebbi state.

Plate 6 Regional map of Kebbi State. Source; retrieved from www.glooge.com, (2017)

Plate 7 Clay site at Birnin kebbi

Plate 8 Clay site at Mungadi

III. Methodology

3.1 Sample collection and preparation

The clay samples were collected from a hand digging of shallow holes which was dug for the purpose of this research in selected local government area of Kebbi state, Nigeria. The entire area is composed relatively of abundant deposits of this clay. The clay sample was collected at random from the dugout soil at the site between depths of about 2 meters to 5 meters. The clay had a slightly visible stratified arrangement of about 4cm to 9cm apart. Once collected the lumps was transported to Kebbi state university of science and technology Aliero, where the samples were crushed and thoroughly mixed by quartering and coning method in order to achieve a representative homogeneous samples.

The clay samples were collected from five different locations on a particular area in order to have a good representation of the site. The two areas were used for the state in order to further give a wider sample spread for the state.

The samples from the five locations on an area were mixed properly and a representative sample from that area was produced using the cone and quartering system as recommended by the American Society of Testing Materials (ASTM) (Abubakar *et al.,* 2014). The process involves mixing the samples and spreading them uniformly and equally into a rectangle. The rectangle is divided into four equal parts and two alternate portions were taken, then mixed properly and form into a cone. The cone was also divided into four equal parts while the alternate portion was further being taken. This process of mixing properly, spreading into rectangular shapes and cones and taking the alternate portions continued until a sizable quantity sufficient for the tests to be carried out is produce (Abubakar *et al.*, 2014).

3.2 Determination of Thermal Properties

Thermo gravimetric Analysis (TGA)

TGA is a method of thermal analysis in which changes in physical and chemical properties of material are measures as a function increasing temperature or is a function of time.TGA can provide information about physical phenomena such as second- order phase, transition, sublimation, adsorption, absorption and desorption (Aliyu *et al.*, 2013).

Differential Thermal Analysis (DTA)

Differential thermal analysis **(DTA),** in analytical chemistry, a technique for identifying and quantitatively analyzing the chemical composition of substances by observing the thermal behavior of a sample as it is heated. The technique is based on the fact that as a substance is heated, it undergoes reactions and phase changes that involves absorption or emission of heat. In DTA the temperature of the test material is measured relative to that of an adjacent inert material. A thermocouple imbedded in the test piece and another in the inert material are connected so that any differential temperatures generated during the heating cycle are graphically recorded as a series of peaks on a moving chart. The amount of heat involved and temperature at which these changes take place are characteristic of individual elements or compounds; identification of a substance, therefore, is accomplished by comparing DTA curves obtained from the unknown with those of known elements or compounds. Moreover, the amounts of a substance present in a composite sample will be related to the area under the peaks in the graph, and this amount can be determined by comparing the area of a characteristic peak with areas from a series of standard samples analyzed under identical conditions. The DTA technique is widely used for identifying minerals and mineral mixtures (Aliyu *et al.*, 2013).

3.3 Determination of Minerals Phase

The untreated clay sample was analyzed using an XRD to determine its mineralogical constituents. The raw clay was crushed and pulverized and prepared base on the principle of sedimentation. The sample was place on the specimen holder of a Diffractometer. The type PX1800 Diffractometer is however control by a computer. It has an automatic divergence and scatter slit of 1.00 degrees each and a receiving slit of 0.300mm and a Cu anode emitting primary X-Rays of wavelengths of $\lambda1$ =1.54056 Å and $\lambda2$ = 1.54439 Å. The machine operated at 40kV and a current of 30mA. The automatic scanning routines allow for values of 2θ from 20 to 650 using a step size of 0.020 and time per step of 0.24 with a peak search intensity threshold of 30 per mile (Abubakar *et al.*, 2014).

IV. Results And Discussion

4.1 Results

The results of the thermal analysis using both TGA and DTA techniques were depicted in figures 1 and 2 for the two samples, while the % wt. Composition of the samples was given in table 1.

Table 1: % wt. Composition of the samples by TGA and DTA

Parameter (% wt)	Birnin kebbi (A)	Mungadi (B)
Clay (Halloysite)	**2.732**	**4.01**
Clay (Kaolinite)	**3.4914**	**3.7889**
$CaCO_3$	**65.87**	**38.43**

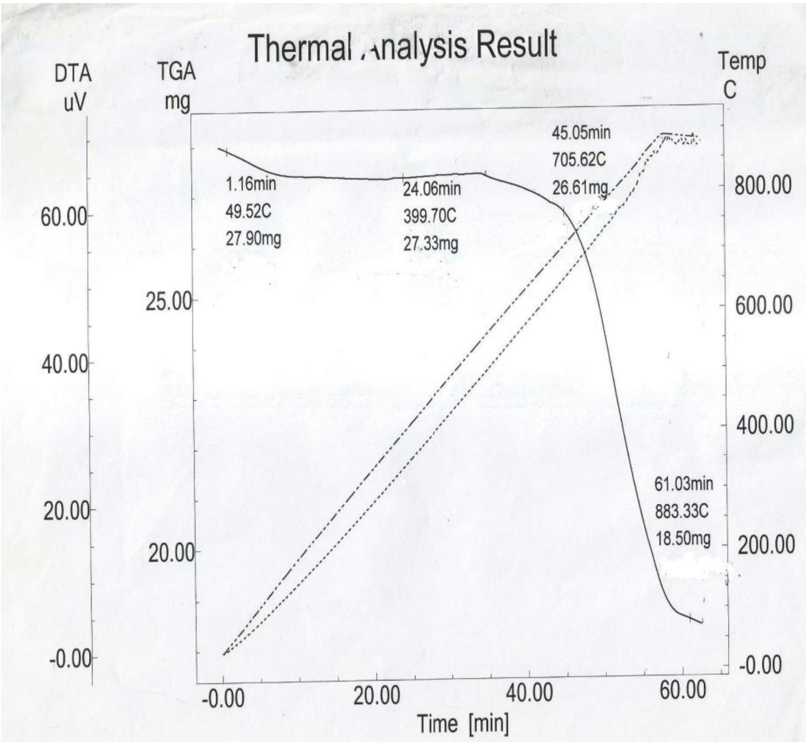

Figure 1 DTA and TGA for samples (A)

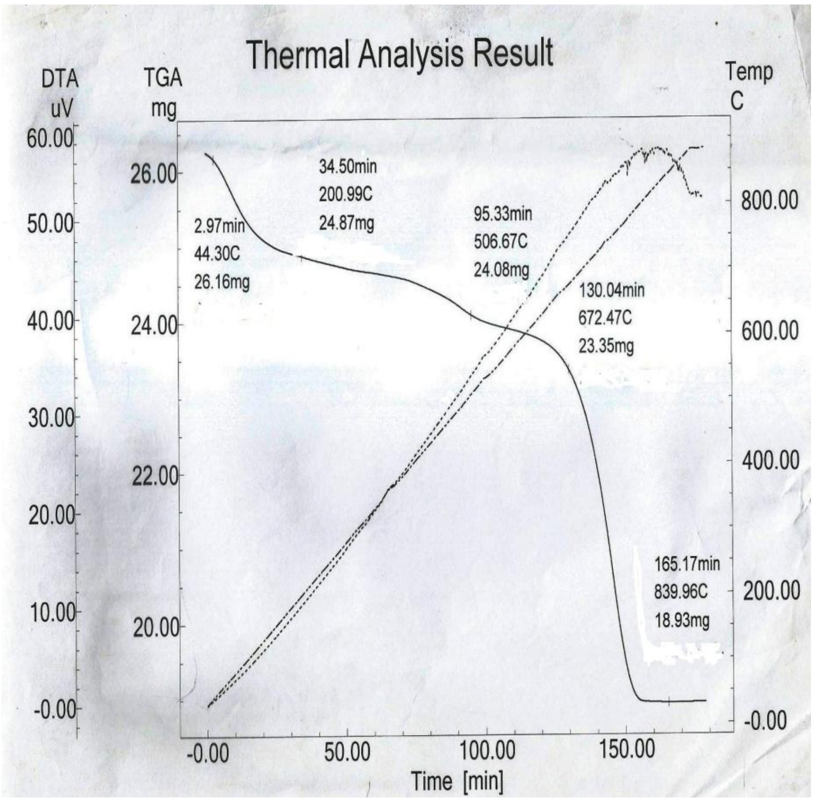

Figure 2 DTA and TGA Results for Sample B

4.2 DISCUSSION

Halloysite shows an endothermic peak at (399.70^{o}C and 506.67^{o}C) the curve (A, &B) Shown these finding for sample A and sample B respectively. The endothermic reaction corresponds to the hydration of the material. The % weight is listed in table 1.

AL (OH) 3→ ALO (OH) +H_2O (1)

Kaolinite undergoes endothermic reaction at temperature 705.62^{o}C and 672.47^{o}C .The curve (A and B) shows these finding for sample A and sample B respectively. The endothermic reaction corresponds to the hydration of the material. The %weight is presented in the table 1.

$Al_2O_3.2SiO_2.2H_2O \rightarrow Al_2O_32SiO_2+2H_2O$ (2)

The decomposition of CaCO3 for temperatures 883.330C and 839.96^{0}C. The curve (A and B) show these finding for sample A and sample B respectively, the endothermic reaction correspond to the decomposition of the material. The % weights of $CaCO_3$ are shown in the table1.

Looking at table 1, clay sample A has the least amount of Halloysite clay than Sample B with value of 2.732 and 4.1 respectively. Therefore, clay sample B has the highest amount of Halloysite and it can be best raw material for industrial application in the absence of kaolinite.

Sample A clay has the least amount of kaolinite than Sample B with amount correspond to 3.4914 and 3.788 respectively. Therefore, Sample B clay has the highest amount of kaolinite clay.

Sample B had the least amount of $CaCO_3$ than Sample B, with amount 38.43%, and 65.871%, respectively. Therefore, sample A clay has the highest amount of $CaCO_3$ with 65.871% then Sample B. Sample A clay is a raw material for the production of low grade cement. It's a best building & construction raw material than sample B.

X- Ray Diffraction Analysis Results

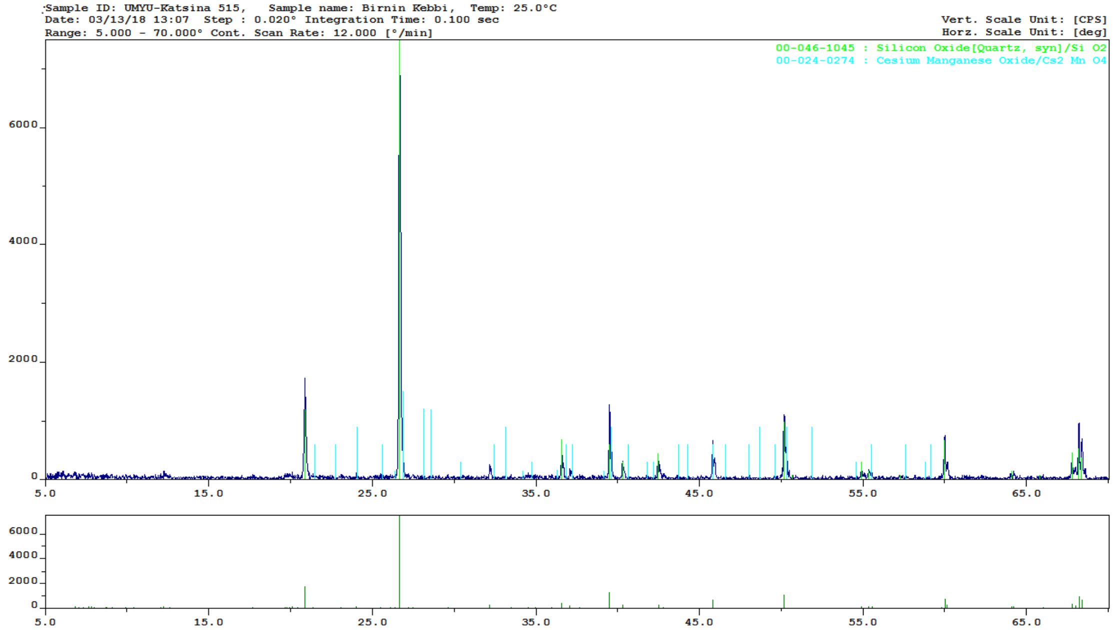

Figure 3:X- ray Diffraction for Sample A

The results obtained shows that sample A contains primary two major compound silicon oxides and cesium manganese oxide. The silicon oxide has the chemical formula SiO_2 with weight % O 53.26 Si 46.74 and atomic % O 66.67 Si 33.33 with molecular weight of 60.08g/mol. the mineral contain of this compound are Quartz and synthetic. The crystal structure of the compound is centrosymmetric and the system is hexagonal. This compound is in phase range between 00-046-1045. The second compound is cesium manganese oxides with chemical formula Cs_2MnO_2 with weight% Cs 69.09 Mn 14.28 and O 16.63 and atomic % of Cs 28.57 Mn 14.29 and O 57.14 with molecular weight of 384.75g/mol, the crystal structure was centrosymmetric, the system is orthorhombic.

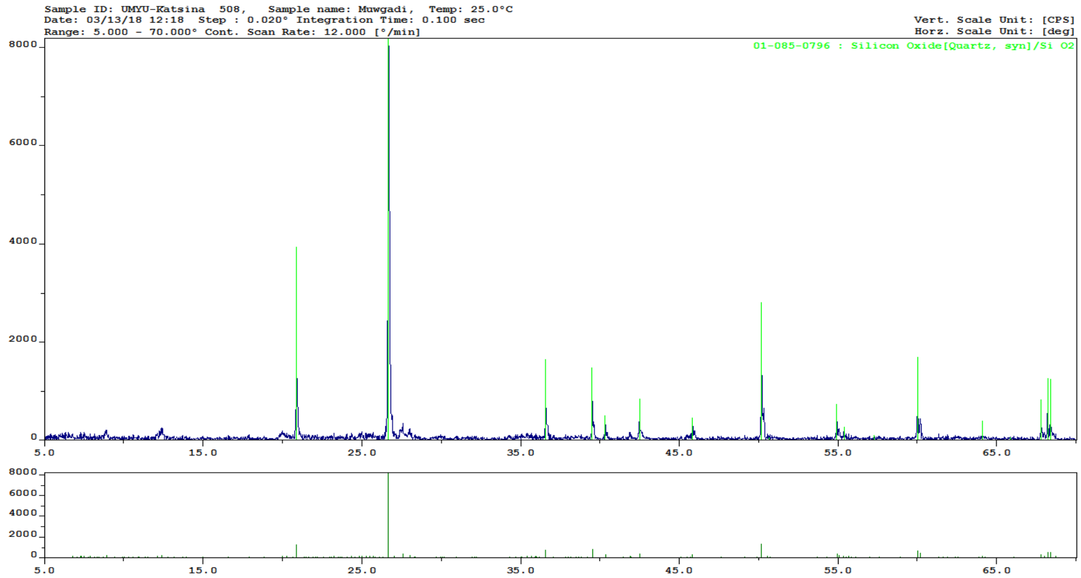

Figure 2 Clay sample B X-ray Diffraction pattern.

The figure above show the x-ray diffraction pattern of sample B, this compound is in mineral phase range of 01-085-0796. This compound has two clay minerals Quartz and synthetic, the silicon oxide compound has chemical formula SiO_2, in the phase range from 01-085-0796. It has the atomic weight %of , O 53.26, Si 46.74 and atomic mass % of O 66.67 Si 33.33. The system is hexagonal with molecular weight 60.08g/mol. The crystal structure is centrosymmetric.

V. Conclusion

Clay sample A had the least amount of Halloysite clay than Sample B with value of 2.732and 4.1 respectively. Therefore, Sample B clay has the highest amount of Halloysite and it can be best raw material for industrial application in the absence of kaolinite .Sample A has the least amount of kaolinite than Sample B with amount corresponds to 3.4914 and 3.788 respectively. Therefore, Sample B has the highest amount of kaolinite clay therefore its best uses for industrial application in area like paper industries, paint; ceramic e.t.c. Sample B clay had the least amount of $CaCO_3$ than Sample A, with amount 65.87% and 38.43%, respectively. Therefore, clay sample A has the highest amount of $CaCO_3$ with 65.871% then Sample B. clay sample A is a raw material for the production of low grade cement. It's a best building & construction raw material than clay sample B. The Diffraction pattern of clay Sample A, has shown that the clay has two compound that are in phase while Sample B has only one compound.

Reference

[1]. Abia-Bassey, N., Ewurum, M., and Ume, J. (2010). The Characterization of New Clay For the Promotion of Local Ceramic Industries. *Ceramic Association of Nigeria National Conferences Akure*, Nigeria.

[2]. Abubakar, U. B., U. Z, S. S., N., and N., S. (2014). Characteristic of Debagi Clay Deposit for its ceramic potential. *African Journal of Environmental Science and Technology*. Vol.3 22-26

[3]. Aliyu, S., Garba, B., Isah, A., and Danshehu, B. (2013). Chemical and Physical Characteristics of Selected Clay Samples. *Engineering Research and Technology.* Sokoto Nigeria Vol 1. 7-9

[4]. ASTM 2487. (2006). Standard Practice For Classification of Soil For Engineering Purpose. *ASTM.* Califonia, America Publish Code.

[5]. Fakulojo, O., Olokode, O., Alyedum, P., Oyeleke, Y., Anyawu, B., and Lee, W. (2012). Studies on the five Selected Clays in Abeokuta. *Pacific Journal of Science and Technology, 13(1),* 83-89.

[6]. Kitoumi, S., and Harabi, A. (2001). Ceramic, Unpublished Material.

[7]. Mogda, K., Maria, T., Janos K., and Gabor, K., (1995). Thermal Behaviour and Decomposition of intercalated kaolinite. *Journal of clays and clay mineral.vol. 43. No.2* 223-228

[8]. Ralph, E., Grim, D. and Richard, A.. (2011). Diffrential Thermal Analysis of clay mineral And other hydrous material. *J. Eng. Thermophys.24*;670-699

[9]. Souse, S. G., and Holanda, J. F. (2011). Ceramica. *Journal of Natural Resource*, Accra, Ghana, vol. 2 50-55.

[10]. Xiang, l., Yang, L., Bao, M., Wei W., and Shou W., (2013). Decomposition kinetic characteristic of calcium carbonate containing organic acid by TGA. *Arabian journal of chemistry*. Http;//doi.org//0'.1016/j.arabje;2016:09:026.

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