# ChemiCal analysis TesT On auChi BlaCk Clay and AfowA white ClAy

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**Abstract**

*This study is basically exploring the ceramic properties in various local raw materials available in Etsako West Local Government, Edo State. The raw materials investigated are the Auchi black clay and Afowa white clay. Clay occur so widely in nature, and are now so extensively used both directly and indirectly as man extends his control over the surface of the earth. Clay was formerly thought of as mass in its physical make up, but later studies indicated that these are colloids. These particles are chiefly responsible for the physical properties of clays. The particles size differs depending on how the clay in question is formed. Based on geologic history, clay has been divided into two, primary and secondary clays. This paper therefore is basically on the chemical analysis of Auchi black clay and Afowa white clays. In view of the above facts, the samples investigated were subjected to both physical and chemical tests comprising visual test, sieve analysis, plasticity, loss-on-ignition and water absorption test to determine their chemical composition and presence of impurities like iron oxides, Carbonaceous materials and alkaline.*

**Keyword**: Clay, analysis, physical, chemical properties

Clay is a hydrated aluminum silicate expressed chemically as $Al_2O_3$ $2S_1O_2$ $2H_2O$. Clay is basically made up of Alumina, Silica and chemical water other oxides present in it could be considered to be impurities. There two types clay, secondary clays (Ball clay) and primary clays (kaolin or china clays). Kashim, (2001) affirmed that secondary clay is found everywhere in Nigeria, ball clay is characterized by their fine size and often high content of organic material, although the clay mineral is kaolinite. Ball clays are usually of high dry and fired strength than china clay. It contains a greater quality and variety of impurity than china clays. Kaolin is refractory clay, whitish in colour, not very plastic, of low shrinkage and contains less impurity.

According to Hornby (2006) impurity is a substance that is present in small amount in another substance, making it dirty or of poor quality. Since clay is required

in its pure states it is therefore very important to know the level of impurity of particular clay to determine the suitability in the ceramic industries.

This paper therefore focuses on analyzing the Auchi black and Afowa white clays to determine the chemical contents. As a result Samples of Auchi and Afowa clays were subjected to physical and chemical test, comprising visual test, sieve analysis, plasticity, and loss-on-ignition and water absorption test. This is to determine their chemical composition, presence of impurities like iron, titanium oxides and carbonaceous materials and alkaline content in various clays.

**Chemical Analysis**

**Volumetric**

Chemical analysis was carried out on the two samples of clay under study i.e. the black clay from Auchi and Afowa white clay.The analysis was carried out in the quality control laboratory of Okpella cement company, Okpella. The tests for various materials in the clay composition were carried out as follows:

**1. Silica ($S_i0_2$)**

A sample for chemical analysis is prepared by grinding thoroughly a quartered sample and passing through 90µm mesh sieve 1 gram of prepared sample is weighed in a platinum crucible. This is thoroughly mixed with 3 gram $Na_2c0_3$ and then covered up with 1 gram $Na_2C0_3$. This fused in a muffle kiln at a temperature of 1000$^o$C for 30 minutes. The contents were washed with 10 ml con. HCL into porcelain dish and made up to 75 ml with acidified (5% HCL) water on a hot plate over night to bake.

The baked sample is dissolved with 5% HCL, heated and filtered into 500 ml volumetric flask, using a white band filter paper No. 541. The precipitates are washed with warm 5% HCL and then 3 times with hot distilled water. The filtrate is made up to 500ml mark with distilled water; the filter paper and residue are transferred into a weighed platinum crucible.

This is ignited slowly to burn off carbon and finally at 1150$^o$C for 30 minutes. Cooled in desiccators to room temperature and weighed.

Weight of Sil0ica x 100 = silica.

**2. Lime (CaO)**

25ml of the filtrate in (1) is pipette into a 250ml beaker and made up to 100 ml with distilled water. 20 drops of triethanolamine added and the solution stirred well using magnetic stirrer, potassium hydroxide is added till the pH of the solution is 12. A small amount of calcene indicator (0.06gm) added and titrated against 0.05M, titriplex XIII (E.D.T.A)

END PT. Green Violet.

Titre x 5.608 = percentage (CaO)

ED.T.A (Ethylenediamine tetra acetic acid)

**3. Magnesium Oxide (MgO)**

25ml of the filtrate in (1) is pipette into 250 ml beaker and made up to 100ml and distilled water. "O drops of triethanolemine added and the solution made up to 9 pH of 10 by adding Buffer solution $NH_4Cl/N/NhyOH$). A pinch of methothynol blue indicator is added and solution turns to blue.

Titrate against Tritriplex XIII

END PT. Blue to Violet

Titre x 4.032 = % Magnesium Oxide (mgo).

**4. Iron III Oxide ($Fe_20_3$)**

100ml of the filtrate in (1) is pipette into a 250 ml beaker and 10ml of ammonium thiocynide ($NH^4SCN$) is added and the solution turns bricked due to complex formation. Sodium a Cetate is added drop by drop until a pH of 2 is obtained. This heated to about 40-50$^oC$ and titrated against tritriplex XIII

END PT RED – YELLOW

Titre x 1.996 = % $Fe_20_3$

**5. Titanium Oxide $Ti0_2$**

One or two drops of $H_2O_2$ is added to Titanium oxide Ti $O_2$ and stirred for 2 minutes and the solution turns to intense yellow. This is titrated against titriplex XIII.

END PT. Colour change – intense yellow – light yellow

Light yellow

Titre x 1.996 = % $Ti0_2$

**6. Alumina ($Ai_2O_3$)**

To the above solution in (5), 15 ml ammonium ethanoate solution is added to bring the pH to 3 and boiled thoroughly. One drop of $CaSO_4$ and 10-15 drops of pan indicator is added and the solution which turns red.

This is titrated against titriplex XIII while boiling until an end pt. is obtained. END PT. Colour remains permanent yellow after further heating

**7. Loss on Ignition**

1 gram of sample is weighed into a weighed platinum crucible and heated at a temperature of 900 – 950$^oC$ for 20 minutes. This is removed and cooled in the desecrator for 10-15 minutes and weighed.

L.O.I % = Difference in wt x 100

Difference in wt before heating – wt after heating

The results of the above test are quoted in percentage for both the Black clay from Auchi, and the white clay from Afowa.

The result of the test gave the following the quantities of each material in the clay composition.

**Afowa White Clay**

| | | |
|---|---|---|
| Silica ($S_2O_2$) | 48.2% | |
| Loss-on-Ignition (L.O.I) | 9.9% | |
| Lime (CaO) | | 1.4% |
| Magnesium Oxide (MgO) | 2.0% | |
| Iron Oxide ($Fe_2O_3$) | | 1.5% |
| Alumina ($Al_2O_3$) | | 36.0% |
| Undetermined (U.D) | 1.0% | |
| | | 100.0% |

**Note**

L. O. I. represents a loss in weight when the material sample is subjected to a temperature of about 1000$^o$C. During this temperature, decomposition and oxidation of some compounds and elements took place.

This is usually done to have an idea of the percentage loss that occurred since material samples are usually fused for analysis at that temperature.

U.D. represents the alkalis ($K_20$ $Na_2O$)

**Auchi Black Clay**

| | | |
|---|---|---|
| Silica ($SiO_2$) | | 63.9% |
| Loss on ignition (L.O.I) | 9.8% | |
| Lime (CaO) | | 1.6% |
| Magnesium Oxide (MgO) | 1.7% | |
| Iron Oxide ($Fe_2O_3$) | | 2.0% |
| Alumina $Ai_2O_3$ | 20.0% | |
| Undetermined (U.D) | 1.0% | |
| | | 100.0% |

**Note**

L.O.I represents a loss in weight when the material sample is subjected to a temperature of about 1000$^o$C. During this temperature, decomposition and oxidation of some compounds and elements took place. This is usually done to have an idea of the percentage loss that occurs since materials samples are usually fused for analysis at that temperature.

U. D. percentage of the alkalis ($K_2O$ $Na_2O$). The percentages of the alkalis are found not to exceed 1% for the three samples.

**Rational Analysis;** Rational analysis is the calculation of mineralogical composition from chemical data.

**Afowa White Clay**

To calculate the Rational Analysis of clay.

**1. Feldspar Convection**

Using this convection, it is assumed that the alkaline ($K_2O$) and $Na_2O$) are derived entirely from feldspars.

1 mole $K_2O$ = 1 mole potash feldspar

= $K_2O$ $Ai_2O_3$ $6SiO_2$

94 parts $K_2O$ = 56 parts of potash feldspars

1 part $K_2O$ = $\frac{556}{94}$ parts of potash feldspars

= 5.92 of potash feldspar

A similar calculation for soda feldspar (albite)

1 mole NaO = 1 mole soda feldspar

= $Na_2O$ $Ai_2O_3$ $6SiO_2$

62 parts $Na_2O$ = 5.243

1 part $Na_2O$ = $\frac{524}{62}$ parts soda feldspar

= 8.45

($K_2O$ + $Na_2O$) = (total alkali content in sample)

1 x 5.92 = 5.92% feldspar.

2. A. 1 molecule $K_2O$ $AI_2O_3$ $6SiO_2$ = 1 mole $Ai_2O_3$ 556 = 102

1 part feldspar – 102 parts AI203

$\frac{556}{}$

= 0.183 $AI_2O_2$

5.92 x 0.183 parts AI203 in feldspar

2. B. Similarly 556 feldspar = 6 x 60 $SiO_2$

1 feldspar = $\frac{360}{556}$ $SiO_2$ = 0.647 $SiO_2$

0.92 x 0.647 = 3.83 parts

$SiO_2$ is feldspar

3. Total $AI_2O_3$ in feldspar = 1.08 = 36 - 10.08

1 molecule $AI_2O_3$ = 1 molecule $AI_2O_3$ $2SiO_2$ – $2H_2O$ + 102 + 258

1 part $AI_2O_3$ = 258 parts clay substance
102
= 2.53 clay substance

Therefore, 34.92 x 2.53 = 88.34% clay substance

4. 1 mole $AI_2O_3$ $2SiO_2$ $2H_2O$ = 2 molecules $SiO_2$

258 = 2 x 60

1 clay substance = 120 $SiO_2$
258

= 0.465 $SiO_2$

Therefore, $SiO_2$ in clay substance = 88.34 x 0.465

= 41.07% $SiO_2$ in clay substance

Free quarts = total $SiO_2$

($SiO_2$ in clay substance + $SiO_2$ in feldspar = 48.2% - (41.07 + 3.83) = 3.3% free quartz.

**Summary**
Total alkalis x 5.92 = % feldspar

Feldspar x 0.183 = $AI_2O_3$ in feldspar) x 2.53 = % clay substance

Clay substance x 0.465 = $SiO_2$ in clay

Total $SiO_2$ – ($SiO_2$ in clay + $SiO_2$ in feldspar)

= % quartz

To calculate the percentage loss-on-ignition, the first step is to calculate the loss due to the chemically combine water in the clay molecule.
1 molecule of $AI_2O_3$, $2SiO_2$ $2H_2O$ = 2 molecule $H_2O$, 258 = 2 x 18
1 part of clay = 36 parts water
258

0.140 parts water
88.34 x 0.140 = 1237 loss due to
$H_2O$ in clay molecule
Total loss = loss due to $H_2O$ in clay +
Loss due to organic matter, $Co_2$ etc.

Therefore, the final rational analysis may be written as:

| | |
|---|---|
| Clay substance | 47.87% |
| Feldspar | 5.9% |
| Quartz | 37.82 |
| $Fe_2O_3$ | 2% |
| MgO | 1.7% |
| CaO | 1.6% |
| Organic matter $Co_2$ | 3.1% |

**Observation**

From the rational analysis calculation, it is observed that the Black clay from Auchi has a low clay substance 47.87% as against the white clay from 88.35% Afowa and high free quartz 37.82%.

**Particle Size Distribution;** The particle size distribution of result above shows that Afowa white clay has finer particles than Auchi black clay, which contravenes expectations, coarse particles are absent. The black clay is found to contain a lot of silt than clay content. Liquid limit is high 70 – 80% the clay activity is 0.8 – 0.9%. The rational analysis gives the clay content as 47.87%. The free quartz in this clay is in large amount (37.82%), which depicts good clay for silica refractories and could be mixed with mineralizing like Calcium oxide (CaO) to produce good refractory bricks. This mineralizes e.g. CaO could help to stop the excessive cracking of products made from this clay.

**Conclusion**

The result of loss on ignition tests carried out on black and white clays, shows a higher loss on ignition on black clay than the white clay, which could be due to the presence of too much carbonaceous material in the clay structure and moisture in the black clay. This appears to be good clay for ceramic forming processes.

Weight at bone dry = 43.95 gram
Weight after firing = 35 grams
Weight Loss = 8.95

**Recommendations**

(1) It is finally recommended that within the limits of experimental error, this clay when mixed with dolomite or calcium carbonate could be used for sanitary wares as well as tableware in ceramics.

(2) The white clay has clay substance of 88.3% and this could be ideal for paper and pulp, pharmaceutical industries, paint industries as well as Ceramic Industries.

However, the iron content which is 1.5% could be removed by magnetism; this is good Kaolinites clay for all industrial uses.

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