Particle size distribution and physico-chemical composition of clay.

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Abstract

Clay samples of different particle sizes were obtained by wet sieving and investigated for their chemical composition. They were fractions of <300μm, <106μm, <63μm, and <44μm. Aliquots obtained after acid digestion of clay samples were used in determining the elements by Atomic Absorption Spectrophotometer (AAS) and flame photometry. Loss on Ignition (LOI) was by gravimetry. The data obtained on the alkaline metals, alkali metals, silica, sesquioxides/titanium, pH and Loss on ignition (LOI) reveal a general reduction in composition as particles sizes reduces. However, Mg (MgO) increased (16.09% - 30.86%) through <300μm to <44μm as sieved sizes reduces.

INTRODUCTION

Clays are widely utilized in many facets of our society. Some of the areas can be in ceramics, paper, paint, drilling fluids, foundry bondants, chemical carriers, liquid barriers, decolourization, catalysis and polymers (plastics and rubbers)[1,2]. Many of these applications are dependent on the constituents of the clay [3]. The physical and chemical compositions are intimately related to these applications[4]. Though some constituents have detrimental effect on products developed if not removed before application.

Moreso, because practically no deposit is naturally pure removal of unwanted constituents from the clay materials before application have become relevant in these large varieties of applications. In polymers, clays are used as functional fillers. It is important as a semi-reinforcing/reinforcing filler for both natural and synthetic rubber[5,6]. However, the presence of certain metals such as iron (Fe) and titanium (Ti) affect the products deleteriously as these metals and their oxides act as pro-oxidants, thereby leading to degradation. These metals also affect the colour and brightness of clays[7]. Because of these effects the clay is usually beneficiated so as to remove these impurities through pulverization and sieving. Pulverization frees the impurities so they can be removed by subsequent sieving. Sieving has been used to classify soil materials into fine, medium and coarse particle sizes[8]. Sieving is also used in degritting/screening and dewatering processes as it has been found to improve colour and filling enhancement of clays into paper [9].

In this work sieve of different size is used as a means of removing un-wanted substances from clay after pulverizing so as to obtain cleaner materials that could find use as filler in rubber.

EXPERIMENTAL

The clay sample was collected from a deposit situated at Ugbegun, Edo Central Senatorial district of Nigeria [location (Global Positioning System, GPS: 6° 13’ 39.2” N; 06° 39’ 05.3”E); elevation of 259m above sea level (ASL)], air dried and pulverized. The clay was

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dissolved in water and the slurry sieved through different sieve sizes of 300µm, 106µm, 63µm and 44µm meshes [7,8,9,10], and non clayed materials retained by the sieve discarded. The obtained cleaner clay was oven dried at 100°C for 24 hr. These were pulverized and their chemical compositions determined.

Extraction for analysis

10.0g sieved clay sample was acid (HNO_3) digested and shaken for 30 minutes, at 150° – 155°C until solution became clear. This was made to 100 mls with distilled water and filtered. The aliquots obtained from the mixture were used for analyses. This was done for all the fractions.

Chemical analyses

Si, Al, Fe, Ti, Ca, and Mg were determined on the <300µm, <106µm, <63µm, and <44µm using Atomic Absorption Spectrophotometer (AAS), Buch Scientific, model 210 VGP instrument, while Na and K were by Flame emission spectrophotometer (Jenway, model PF P7) machine, loss on Ignition was by gravimetry and pH by Jenway pH meter.

RESULTS AND DISCUSSION

Chemical composition of the crude clay is shown Table 1 and the 4 Nos. sieved different particle fractions Figs. 1-4. These compositions are necessary analyses for evaluating clay before application. The elements usually represented in their oxides play a key role in clay assessment in evaluation for various applications where it may find acceptability, which could range from house hold to industrial wares.

Fig.1 shows the silica (SiO_2), sesquioxides (Al_2O_3 + Fe_2O_3) and titanium oxides (TiO_2) of fractions of the sieved clay. The silica (SiO_2) was 36.92%, 35.10%, 30.05% and 5.62% for the <300µm, <106µm, <63µm and <44µm respectively. There was no remarkable difference in silica (SiO_2) as particle fractions reduced from < 300µm - < 106µm - < 63µm but an observed 15.22% reduction in the silica content of the < 44µm when compared to that of the crude clay. Alumina (Al_2O_3) reduced through the fractions indicating 9.64%, 7.56%, 5.10%, 1.89% for particle fractions < 300µm, <106µm, <63µm and < 44µm respectively. The Iron and titanium oxides (Fe_2O_3) and (TiO_2) responsible for the colouration of clay materials were both reduced markedly. Fe_2O_3 were 1.08%, 0.90%, 0.45%, 0.27% and TiO_2; 0.16%, 0.10%, 0.05%, & 0.03% for the particle fractions <300µm, <106µm, 63µm and 44µm.

Table 1.0 Chemical composition of crude clay.

Component	wt (%)
SiO_2	38.48
Al_2O_3	12.46
Fe_2O_3	6.18
TiO_2	1.85
MgO	14.67
CaO	12.05
Na_2O	1.42
K_2O	9.57
*LOI	13.50
pH	7.43

*LOI: loss on ignition.

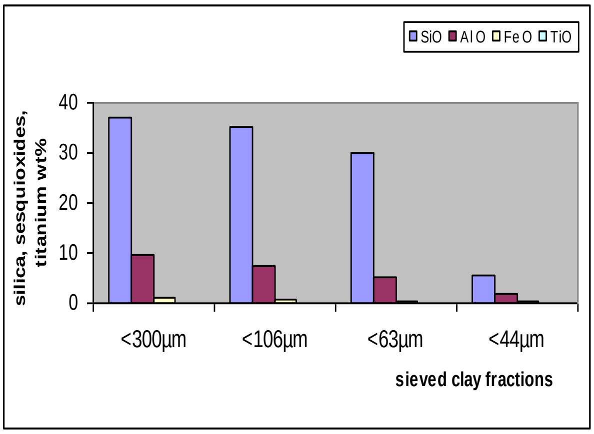

Figure 1. Comparative effect of sieving on silica, sesquioxides (Al_2O_3 + Fe_2O_3) and titanium in clay fractions.

The alkaline earth metals of the various fractions as seizes reduce is shown in Fig. 2. Calcium (CaO) and Magnesium (MgO), which makes up a significant part of the bivalent exchangeable cations, present in the inner clay lattices, were CaO, 11.02%, 6.90%, 3.36%, and 1.01% at <300µm, <106µm, 63µm and 44µm as particle sizes reduced. However, there was an observed remarkable increase in magnesium from 14.67% (crude clay) to 16.09% at fraction <300µm, 18.02% for <106µm, 24.06% for <63µm and 30.86% for <44µm respectively. This phenomenon of Magnesium was a shift from the observed trend of other elemental constituents of the clay as the particle fractions reduces. This occurrence will further be investigated in subsequent studies.

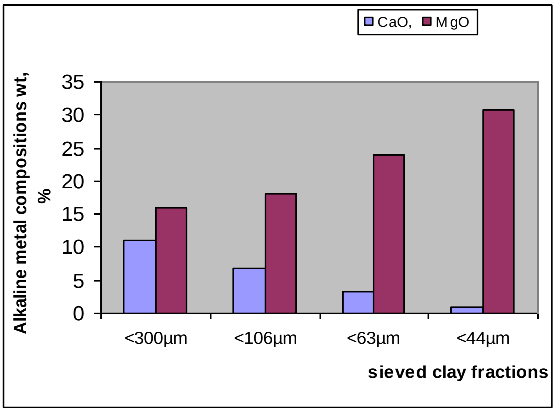

Figure 2. Comparative effect of sieving on alkaline metal in clay fractions.

The alkali metal composition of the sieved clay fractions is depicted in Fig. 3. Sodium (Na_2O) and Potassium (K_2O) characteristic of single electron in their outermost shell indicated a reduction in content. Na_2O was 1.21%, 1.88%, 0.00%, 0.00% and K_2O was 8.57%, 8.16%, 7.70% & 6.19% for the sizes fractions < 300µm, <106µm, <63µm and < 44µm.

The loss on ignition and pH of the <300µm, <106µm, <63µm and <44µm clay fractions is shown in Fig. 4. Loss on ignition (LOI) which is water of constitution [$H_2O(+)$], organic matter and soluble volatile salts decreased across the fraction sizes; 12.5% for <300µm, 10.29% for <106µm, 7.22% for 63µm and 5.10% for <44µm.

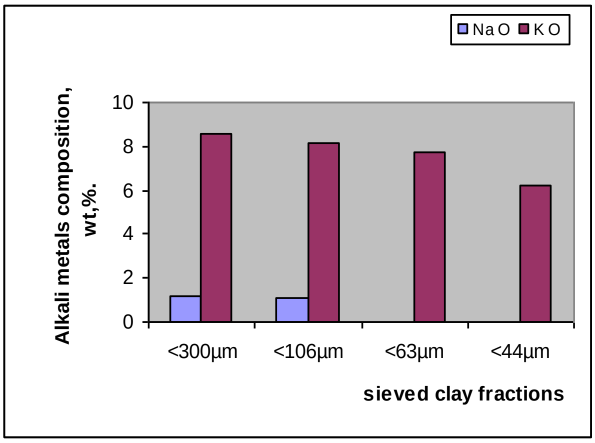

Figure 3. Comparative effect of sieving on alkali metal in clay fractions.

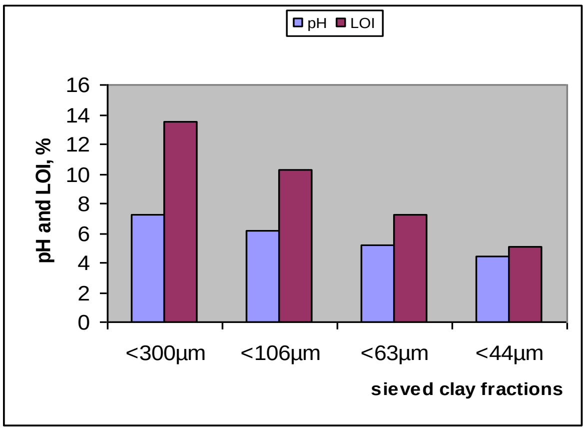

Figure 4. Comparative effect of sieving on pH and LOI of clay fractions

Reduction in pH (the activity of ionized H (H^+) in solution) was noticed in the fractions as sizes decreased, < 300µm; 7.20, < 106µm; 6.2, < 63µm; 5.2, and < 44µm; 4.4. This increase in acidity could be as a result of greater degree of unsaturation of the clay soil, as the exchangeable base content falls (depletion of calcium in the clay).

CONCLUSIONS

Sieving has been shown to aid removal of some un-wanted substances (Fe and Ti) that are deleterious to rubbery products during applications, but it was also observed that some relevant constituents are also washed through the sieves, thereby reducing its composition, particularly at very small sieve fractions (<44µm). However, this shows that there is a corollary between particle sizes and chemical composition (these included alkaline metals, alkali metals, silica, sesquioxides/titanium, pH and Loss on ignition (LOI)] of fractions obtained through wet sieving clay. Perhaps, particle size characterization of earth materials will be necessary in the diagnostic evaluation of material application.

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