CHEMICAL ANALYSIS OF TRONA FOR ITS SUITABILITY IN SODA LIME SILICATE GLASS PRODUCTION

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Abstract
Trona is considered as a type of mineral that contains several carbonates that are formed in a non-marine evaporite deposits. Trona (potash) chemically represented by Na_2CO_3-$NaHCO_3$-$2H_2O$ or [$Na_3(HCO_3)$-(HCO_3)-$(CO_3)(2H_2O)$is one of the complex salts used as a flux in glass production. Trona is also the main ore in the production of soda ash. Fifteen trona samples were collected from fifteen different oases within Yusufari Local Government Area and six of the samples were randomly selected among the fifteen and analyzed for its physicochemical constituents. X-Ray fluorescence Analysis (XRF) and Atomic Absorption Spectrophotometry (AAS) machines were used for the chemical analysis. The results showed clearly that the samples contain a high percentage of sodium Oxide Na_2O in the range of 64.4870 - 69.5748, Silicon dioxide (SiO_2) 22.2102 - 25.6052, Calcium Oxide (CaO) 1.057 – 1.3546), Magnesium Oxide (MgO) 1.4626 - 4.0238), Manganese Oxide (MnO) 0.0114 – 2.1681, Aluminum Oxide (Al_2O_3) 0.2137 – 3.4721), Iron Oxide (Fe_2O_3) 0.6504 – 0.9478 and Potassium Oxide (K_2O) 4.2185 – 5.1388

Introduction
Trona is the type of mineral that contains several Carbonates that are formed in non-marine evaporite deposits. Trona (potash) anhydrous sodium carbonate chemically represented by Na_2CO_3 - $NaHCO_3$ - $2H_2O$ or [$Na_3(HCO_3)$ - (CO_3) $(2H_2O)$] is one of the complex salts used as a flux in glass production. Trona is also the main ore for the production of soda ash. (http://www.solvaychemicals 2006).

Trona is a common household salt in Nigeria second to table salt. It is commonly used for cooking hard food such as skin, bones and as additive to animal feeds. It is popularly known as “kanwa” or “kaun”. Trona occurs as evaporite deposits in areas bordering other countries in the Northern parts of Nigeria in the Lake Chad Basin. It is found in oasis, lakes, fadamas, playas and other depressions where the complex salt is deposited as a result of prolonged evaporation of fluctuating ground water.

Some of the large deposits in Nigeria are found in Yusufari, Machina, Bade (Gashua), Guda, Nguru, Yunusari and Dapchi Local Government Areas in Yobe State, Mayo-Belwa, and Zumo Local Government Areas in Adamawa State and Taraba state respectively, Kukawa, Sule Tankankar, and Kazaure Local Government Areas in Jigawa State of Nigeria.(RMRDC 2004)

Trona is a soft, friable and porous evaporite deposits occurring in association with Gaylussite ($Na_2Ca(CO_3)_2$-$5H_2O$, Natron ($Na_2CO_3.10H_2O$), Pirssonite $Na_2Ca(CO_3)_2$ - $4H_2O$, Nahcolite $NaHCO_3$, Hanksite $Na_{22}K(SO_4)_9(CO_3)_2Cl$, Halite (NaCl) and Borax ($Na_2B_4O_7.10H_2O$). Trona is probably the most common and well known of these minerals. They are all difficult identify except when a good crystal form is present or when Optical or X-ray technique is used. (http://www.
galleries.com/minerals/carbonat/trona/trona.htm. (2012).

Trona samples were collected from fifteen different oases/fadamas which include Furkano, Lawan Gajiram, Kajimaram, Tamsuwa, Kiriram, Ngingudi, Daudaram,

Ngererewa, Ngursuwa, Kwarin Jaji, Maine Kilbou, Wane, Kilbuwa, Kwajimiri and Sosono in Yusufari Local Government Area for chemical analysis. Trona is mined by the local men using diggers, hoes, and shovels. They are packaged in sacks of about 100kg before transported to Gashua, Bade Local Government Area of Yobe State which is the commercial center where marketers come to buy. Trona or soda ash is an economic mineral which when processed is used as a flux in soda-lime silicate glasses and several other applications.

All the glass industries in Nigeria have relied solely on importing soda ash for glass production from North America, Western Europe, Central and Eastern Europe, Japan and China Dennis (2004). This is because there is no viable soda ash processing company in Nigeria at this point in time to process this abundant mineral 'trona' into soda ash. (Philip 1996 and RMRDC 2004).

The Glass manufacturing industries are the largest consumer of soda ash for the production of container glass, fiberglass, insulation glasses, or flat glass for the housing, commercial building, and automotive industries. Dennis (2004), states in his analysis that more than 60 per cent of the world's total soda ash produced is consumed by the glass industries. Glass industries in Nigeria have depended solely on importation of soda ash. It is expensive buying this processed soda ash, when we have abundant deposit of trona/soda in Nigeria which can be processed locally. The aim of this study is to explore the trona deposits in Yusufari Local Government Area, Yobe State, for the purpose of beneficiating and analyzing the chemical constituents for its suitability in soda lime silicate glass production in Nigeria.

The chemical analyses of trona are determined by Atomic Absorption Spectrophotometry (AAS) and X-Ray Fluorescence analysis (XRF) is done on the samples. This study is delimited to analyzing trona from some oases in Yusufari Local Government Area of Yobe state. This is based on the quality and availability of resources. Therefore, this study is delimited to analyzing trona from Furkano, Kajimaram, Kiriram, Ngingudi, Daudaram, and Sosono all in Yusufari, Yobe State for use as a flux in glass production.

Trona formation

Natural sodium deposits are formed by a long geologic process of the erosion of igneous rocks, the transportation of sodium from these rocks, and chemical reactions. First, the sodium is released from igneous rocks when they weather and break down. The sodium is carried by water in rivers, streams, and as runoff and collects in basins. When it comes in contact with carbon dioxide, it precipitates out as sodium carbonate.
(http://eoearth.org/article/soda_ash_or_Trona 2014)

The University of Maiduguri, Geology Department reported in its published findings on the trona deposits in Yobe State that we have an average of 882.8 million tons of trona deposits. Nkereuwem (1994)

Chemical Characteristics of Trona

Chemical formula $Na_3(HCO_3)$-(CO_3) $(2H_2O)$
Composition molecular weight = 226.03gm

Sodium 30.51 % Na	41.13 % Na_2O
Hydrogen 2.23 % H	19.93% H_2O
Carbon 10.63 % C	38.94 % CO_2
Oxygen 56.63 % O	0.0000
Total 100%	100%

(www.galleries.com/mineralscarbonatclass (2012)

Methodology

Fifteen trona samples were collected but six samples were randomly selected using the replacement method (Mbahi 2001). This is because they have similar physical appearance both in grain size and color.

Study Area, Location and Description

Yusufari Local Government area, Yobe State Nigeria is situated at lat.$13^0 05'$ North, Long.$11^0 12'$ East. It has an estimated population of about 30,000. Yusufari is about 18.9 miles from Gashua, Bade Local Government Area which is a commercial center where trona is brought for sale. Gashua has an estimated population of about 100,000. The distance between the oases varies between 5 to 20 miles. The roads to most of the playas are traceable only by the local men and their means of

transportation is either on donkey, camels or four-wheel drive vehicles which are usual means of transportation in the Sahara Desert. With the assistance of a paid guide Mal. Ahmadu Mohammed Gashua and a hired land rover driver, the researcher was able to collect trona samples from 15 different oases/playas within four days. The Trona was collected in the month may as access to this playas is only when the rainy season is over.

Preparation of Samples for Analysis (Digestion)

For X-Ray Fluoresce analysis (**XRF)**, the samples were pulverized to a fine powder and about 20g of each sample was used for the analysis in the powder form. For the analysis using atomic absorption Spectrophotometry (**AAS)** however, the powdered sample was digested and dissolved using di-acid method. 10ml of a mixture of Nitric acid and Hydrochloric acid in a ratio of 1:3 respectively was added to 0.2g of the sample placed in a platinum crucible. The crucible was then heated on a hot plate for about 30 minutes to allow for complete dissolution of the sample. These mixtures were then filtered into a 100ml volumetric flask and then made to volume using distilled water.

Chemical Analysis of Trona Samples

Atomic Absorption Spectrophotometer AAS

The Atomic Absorption Spectrophotometry and X-Ray Florescence Analysis is an analytical method of determining the elements found in minerals which are dissolved or digested.

AAnalyst 400 AAS machine manufactured by Perkin Elmer Company was used for the Atomic Absorption Spectrophotometer analysis.

The Atomic absorption units have four basic parts: interchangeable lamps that emit light with element-specific wavelengths, a sample aspirator, a flame or furnace apparatus for volatilizing the sample, and a photon detector. In order to analyze for any given element, a lamp is chosen to produce a wavelength of light that is absorbed by that element. Sample solutions are aspirated into the flame. If any ions of the given element are present in the flame, they will absorb light produced by the lamp before it reaches the detector. The amount of light absorbed depends on the amount of the element present in the sample. Absorbance values for unknown samples are compared to calibration curves prepared by running known samples. (Richard 1993).

The X-Ray Fluorescence Analysis XRF

The model of the XRF machine used in this analysis is 'Minimate/Minipal' table top type which is a product of **P**ANalytical's **C**ompany. A plastic container with a lid and an X-Ray film **'**Prolene 426**'** were the accessories of the equipment. The MiniPal X-ray tube is designed and optimized for PANalytical's MiniPal and MiniMate Energy Dispersive (EDX) table-top XRF spectrometers. It is a low power (9W) glass side window tube encapsulated in silicone-rubber. Its main features are:

- Glass technology
- Low tube power (9W)
- Si-rubber high voltage insulation
- Various anode types

An X-ray Fluorescence (XRF) spectrometer is an x-ray instrument used for routine, relatively non-destructive chemical analysis of rocks, minerals, sediments and fluids. It works on wavelength dispersive spectroscopic principles that are similar to an electron microprobe. It is typically used for bulk analysis of larger fractions of geological materials. The X-ray fluorescence analysis is relatively easy to use and cheaper; this makes it one of the most used methods for analysis of major and trace elements in rocks, minerals, and sediments. The elements analyzed in this research using the XRF are Si, Al, K, Ca, and Fe.

Loss on Ignition (LOI)

Loss on Ignition was determined by heating 10g of the sample at 105 – 110^0C in a carbolated furnace for 2hr. It was cooled in desiccators and then weighed. The heating is repeated for two hours subsequently until a constant weight is obtained. The difference in weight was estimated in percentage. All the samples A, B, C, D, E and F were treated in the same manner and the results are presented in Tables 1- 6.

Calculation

Weight of empty crucible = W_1 = 53.9908g

Weight of W_1 + sample A = W_2 = 72.1612g
Weight of W_2 after ignition = W_3 = 71.8792g
Loss in weight (LW) = (W_2 - W_3) g = 72.1612 – 71.8792

= 0.2820g

Therefore % LW = $\frac{0.2820 \times 100}{1}$ = 28.20%

The same procedure was followed for all the other samples to obtain the percentage weight loss on ignition; results shown in Tables 1- 6.

Solubility Test

10g of Sample A was introduced into a flat bottom flask and distilled water added and vigorously shaken, it was observed to have dissolved with few sediments found to settle down from impurity which will include silica and other clay bodies. The same procedure was carried out for the other samples. It was observed that all the other samples show the same characteristics.

Results

The results of the analysis are presented in Tables 1 to 6

Conclusions

From the results of chemical analysis of the six trona samples, it shows that sodium oxide Na_2O ranged between 64.4870 - 69.5748, Silicon dioxide (SiO_2) 22.2102 - 25.6052, Calcium Oxide (CaO) 1.057 – 1.3546), Magnesium Oxide (MgO) 1.4626 - 4.0238), Manganese Oxide (MnO) 0.0114 – 2.1681, Aluminum Oxide (Al_2O_3) 0.2137 – 3.4721), Iron Oxide (Fe_2O_3) 0.6504 – 0.9478 and Potassium Oxide (K_2O) 4.2185 – 5.1388. The combined presence of sodium and potassium oxides which are all fluxes in the range of 68.7055 – 74.7136 per cent proves that the trona can be used in the production of soda lime silicate glasses. The iron content is within the tolerable limit.

Recommendation

It is recommended that the glass industries in Nigeria should try using the trona for their soda lime silicate glass production. Government and private individuals can go into the mining of this very important mineral and the creation of companies for processing this abundant mineral that can improve our GDP

Table 1; Sample A

Oxides	**Percentage in sample (%)**
Na_2O	69.5748
SiO_2	22.2102
CaO	1.1079
MgO	1.4628
MnO	2.1681
Al_2O_3	0.2384
Fe_2O_3	0.8109
K_2O	4.6029
Loss on Ignition	28.2000
Solubility Test	soluble in water

Table 2; Sample B

Oxides	**Percentage in sample (%)**
Na_2O	67.2202
SiO_2	23.3872
CaO	1.1124
MgO	1.4626
MnO	0.0114
Al_2O_3	0.2889
Fe_2O_3	0.8439
K_2O	5.1388
Loss on Ignition	25.5000
Solubility Test	soluble in water

Table 3; Sample C

Oxides	**Percentage in sample (%)**
Na_2O	66.8353
SiO_2	22.7179
CaO	1.0570
MgO	3.4650
MnO	0.0151
Al_2O_3	0.3069
Fe_2O_3	0.9187
K_2O	4.6841
Loss on Ignition	29.8000
Solubility Test	soluble in water

Table 4; Sample D

Oxides	**Percentage in sample (%)**
Na_2O	64.5051
SiO_2	25.6052
CaO	1.3546
MgO	2.5031
MnO	0.0220
Al_2O_3	3.4721
Fe_2O_3	0.6504
K_2O	4.8633
Loss on Ignition	24.5000
Solubility Test	soluble in water

Table 5; Sample E

Oxides	**Percentage in sample (%)**
Na_2O	67.4870
SiO_2	23.2604
CaO	1.1248
MgO	3.9120
MnO	0.0194
Al_2O_3	0.2137
Fe_2O_3	0.9478
K_2O	4.2185
Loss on Ignition	25.3000
Solubility Test	soluble in water

Table 6; Sample F

Oxides	**Percentage in sample (%)**
Na_2O	65.9597
SiO_2	23.2604
CaO	1.1293
MgO	4.0238
MnO	0.0178
Al_2O_3	0.3624
Fe_2O_3	0.6780
K_2O	4.5685
Loss on Ignition	24.2000
Solubility Test	soluble in water

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