BENEFICIATION OF DIATOMITE USING HYDROCYCLONE

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ABSTRACT: *Preliminary beneficiation and characterization of the Bularafa of Yobe State diatomite deposit was investigated. A 2" hydrocyclone device having a vertex finder of 8.0mm spigot openings of 3.2mm, 4.5mm, and 6.4mm was used in carrying out the experiment ranging from 1 bar to 5 bars for each spigot opening. The results from the analysis showed a chemical composition of 64.3%* SiO_2*, 1.03%* Al_2O_3*, 5.52%* Fe_2O_3*, 7.09% CaO, 2.00% MgO, 0.60%* K_2O*, 1.29% NaO, 2.10%* T_lO_2*, and 7.10 L 0.1. The result of beneficiation analysis shows that silica (*SiO_2 *) content is 77.20% as highest at 5 bars while the ion oxide (*$Fe_2 O_3$*) is 2.88% the lowest at 5 bar. The result obtained, showed that Bularafa deposit can be used as an insulator, filter, aid, filter and likewise in cement industries.*

Keywords: Diatomite, Hydrocyclone, Fossilized Skeletal and Spigot
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INTRODUCTION

Diatomite (Diatomaceous earth, kieselguhr) is a chalk like, soft, friable, earth, very-fine grained and siliceous sedimentary rock, usually light in colour. It is very finely porous, very low in density and chemically inert in most liquids and gases. It is of low thermal conductivity and a rather high fusion point (Antonides, 1998). According to Valladolid and Perucho (2005), diatomite consists mainly of siliceous shells or skeletons of single-celled organisms called diatoms. It is composed essentially of hydrated amorphous or opalline silica with varying amounts of contaminant materials such as silica sand, clays, salts and organic matter.

The fossilized skeletal remains, a pair of symmetrical shells (frustules), vary in size from less than 1 micro to more than 1 millimeter but are typically 10 to 200 microns across and have a broad variety of delicate lacy, perforated shape from discs and balls to ladders, feathers and needless (Founier, 2004). Chemically, diatomite consists primarily of silicon dioxide, and is essentially inert. It is attacked by strong alkalis and by hydrofluoric acid, but is practically unaffected by other acids. Because of the intricate structure of diatom, skeletons that forms diatomite, the silicon dioxide has very different physical structure from other form in which it occurs. Impurities and other aquatic fossils (sponge residues, radio larian, silio-flagella tae), sand clay, volcanic ash, calcium carbonate, magnesium carbonate, soluble salts and organic matter, variations exist among deposits as well as among parts of the same deposit.

There is a wide range of estimates on the number of diatom species that have existed. Many estimates place the number as high as 100, 000 to 200, 000 different species of this great number, only about 25, 000 bonafide species have actually catalogued and described (Werner, 1977). Deposits of various purities occur in many parts of the world and are occasionally mined only for limited local or special markets. Estimated world reserves are 800 million metric tons (250 million tons in the

United States) which is equivalent to more than 400 times current estimated annual world production of almost 2 million tons (Antomides, 1998). The world reserves based was estimated by the U.S Bureau of mines in 1985 to be almost 2 million tons (Meisinger, 1985).

Commercial deposits worldwide are reported as mostly fresh water lake (Lacustrine) deposits of Miocene to Pleistocene age that is, formed 24 million to 100 thousand years ago, although, the less common oceans (marine) deposits tend to be larger. Geological survey has revealed that Nigeria in its pursuit after development is not left out of countries blessed with this mineral deposit. Diatomite is among such local raw materials found in Bularafa, Yobe State. Owing to its immense application on paper, paint, bricks, tile, ceramics, plastics, soaps, and detergents etc. investigations on its suitability, properties and purifications have not been thoroughly carried out on the various deposits in the country.

Diatomite was apparently used by the ancient Greeks as abrasive and making lightweight building bricks and blocks. Diatomite is now used principally as filtration agent, soft abrasive, industrial filters, and as lightweight aggregate, (Antomides, 1998). In 1995, eighty four percent of all diatomite produced in the U.S was used in three principal areas; as a filter medium, as a filter, and as an insulator. Seventy percent of all production was used in filtering application (Lemous, 1996). These applications vary widely from filtering beverages and food products to swimming pools. As filter, diatomite is used in many applications primarily because it has a low density and relatively inert. It is used as a filter/extender in paints, because of its unique ability to trap pigments helping to distribute the colour evenly throughout the mixture.

The purpose of this research work is to beneficiate the local diatomite in order to remove the various impurities that are present and also to evaluate their chemical properties with the aim of finding out whether it will meet industrial requirement or not.

MATERIALS AND METHODS

Source of Material

The diatomite sample was collected from Bularafa, of Yobe State.

Sample Preparation

The collected sample was first crushed using crushing machine to reduce the size of the diatomite which comes in lump form. The sample was milled to a fine size using ball milling machine. The sample was then sieved on a 200µm sieve size to remove the gasses and other particles that were not reduced as required. Weighed sample of 4.4kg was poured into 40 liters of clean water and agitated properly in order to be classified in communication circuits by using hydrocyclone test rig (Founie, 2004).

Chemical Analysis

Preparation of Stock Solution

About 0.1g of the sample was weighed into a Teflon crucible and it was moistened with aqua regia (mixture of HCl and Nitric acid in the ratio 3:1 by Volume). Acid leaching of the classified products was assessed using two different kinds of acid: hydrochloric acid and sulphuric acid.

Determination of Silica (SiO_2) Content

About 15ml of hydrochloric acid was added to the sample solution and over all mixture then heated in an oven set at 100^0C until the solution becomes clear.

The solution was allowed to cool and it is used in determining Al and Fe.

Determination of Fe_2O_3 Content

About 0.1g of the sample was weighed in a platinum crucible and moistened with concentrated sulphuric acid and 20ml of hydrofluoric acid was added into it. This solution was evaporated to dryness and allowed to cool in a desiccator and weighed to determined percentage of Silica content.

Determination of Calcium Oxide (CaO)

0.2mg of the sample was weighed and digested on a hot plate with 200ml 1:1 HCl and filtered. 30mg of MgCl plus 4ml of KOH was added to the solution to precipitate magnesium hydroxide. After two minutes about 30mg of potassium cyanide and hydroxyl lamine was added and then filtered with 0.01MEDTA using calcon indicator until the colour change from pink to blue.

Determination of Minerals

The minerals in the sample were determined after wet oxidation of the sample using atomic absorption spectrophotometry method (AAS69).

RESULTS

Table 1: For a 2" Hydrocyclone

	A	B	C
Vortex finder (mm)	8.0	8.0	8.0
Spigot opening (mm)	3.2	4.5	6.4

Table 2: For a 3.2mm Spigot Opening and 8mm Vortex

Pressure (Bar)	Flow Rate (l/s)		Flow Rate
	Under flow	Over flow	
1.0	0.056	0.285	5.18
2.0	0.059	0.315	5.34
3.0	0.057	0.318	5.49
4.0	0.058	0.327	5.63
5.0	0.121	0.751	6.21

Table 3: For a 4.5mm Spigot Opening and 8.0mm Vortex

Pressure (Bar)	Flow Rate (l/s)		Flow Rate
	Under Flow	Over Flow	
1.0	0.132	0.276	2.10
2.0	0.145	0.357	2.47
3.0	0.166	0.437	2.63
4.0	0.181	0.477	2.63
5.0	0.193	0.515	2.67

Table 4: For a 6.4mm Spigot Opening and 8.0mm Vortex

Pressure Bar	Flow Rate (l/s)		Flow Rate
	Under Flow	Over Flow	
1.0	0.207	0.229	1.10
2.0	0.214	0.276	1.29
3.0	0.240	0.354	1.47
4.0	0.300	0.450	1.34
5.0	0.396	0.440	1.11

Table 5: Chemical Analysis of Crude Diatomite

Compound	Composition %
SiO_2	64.30
Al_2O_3	1.03
Fe_2O_3	5.52
CaO	7.09
MgO	2.00
K_2O	0.60
Na_2O	1.29
T_lO_2	2.10
L0.1	7.10

Table 6: Chemical Analysis of Beneficiated Diatomite

Sample	SiO_2 (%)	Fe_2O_3 (%)	Al_2O_3 (%)	CaO(%)
A_1	69.20	3.99	7.69	0.24
A_2	59.40	3.80	-	-
A_3	20.00	3.78	-	-
A_4	72.40	3.60	-	-
A_5	74.40	3.59	6.63	0.24
B_1	66.10	3.88	-	-
B_2	67.00	3.10	-	-
B_3	76.50	2.79	6.19	0.24
B_4	76.60	2.81	-	-
B_5	77.20	2.88	-	-
C_1	52.50	3.79	7.75	0.28
C_2	70.40	3.31	-	-
C_3	70.30	3.20	-	-
C_4	72.50	2.76	-	-
C_5	76.00	2.99	6.38	0.56

A_1-A_5 = 3.2mm spigot at different pressures ranging from 1-5 bar.
B_1-B_5= 4.5mm spigot at different pressures ranging from 1-5 bar.
C_1-C_5 = 6.4mm spigot at different pressures ranging from 1-5 bar.

DISCUSSION

The dynamic characteristic of the 20 hydrocyclone having a vortex finder of 8.0mm (in table 2,3, and 4) is found to increase both the under flow and over flow for each of the spigot openings (6.4mm, 4.5mm, and 3.2mm). Likewise, there is a slight increase in the flow ratios (overflow/underflow) for each of the spigot openings with 3.2mm spigot opening having an average of 5.72, 4.5mm spigot opening with 1.26 respectively.

The data in table 5 shows the chemical analysis of crude diatomite sample from Bularafa, of Yobe State. It was observed that the diatomite contains 64.30% SiO_2 and 5.52% Fe_2O_3, which constitute the major concentrate and impurity respectively. Other compositions such as Al_2O_3, Na_2O, CaO, K_2O, MgO, T_lO_2, are found to be 1.03, 1.29, 7.09, 0.60, 2.00, and 2.10% respectively.

The chemical analysis for the beneficiated diatomite in fig 6 showed that there is increase in silica content with increase in pressure where there is a decrease in composition of Fe_2O_3 and Al_2O_3 with increase in pressure for each of the spigot openings, composition of CaO is relatively constant with increase in pressure.

Chemical analysis from the 3.2mm spigot opening showed that the highest concentration of SiO_2 is 74.4% at 5 bars and the lowest concentration of 59.40% at 2 bars which may be due to the unequal particle size distribution. A low Fe_2O_3 content is about 3.59% is also found at 5 bar likewise Al_2O_3 content of 6.63% is recorded at the same pressure. This therefore suggests that when treating diatomite in a 2" hydrocyclone with 3.2mm, spigot opening at 5 bars is the preferred pressure that will give a more efficient separation.

Chemical analysis for 4.5mm from speed opening showed that 77.20% SiO_2 content is the highest at 5 bar where as 66.10% is the lowest at 1 bar. The highest and lowest composition of Fe_2O_3 is 3.88% and 2.79% respectively. This also suggests that opening at 5 bars will give a more efficient separation using a 4.5mm spigot opening. For the 6.4mm spigot opening, a high silica content of 77.2 % found at 5 bars whereas the lowest is 52.50% at 1 bar, which is also due to the unequal particle size distribution. A Fe_2SO_3 content of 3.79% and 2.99% is found representing the highest and lowest concentration respectively. Alumina is also found to reduce to 6.38% at 5 bars from 7.75% at 1 bar.

CONCLUSION

The results showed that the highest degree of separation of impurities from diatomite from Bularafa using a 2" hydrocyclone with 8.0mm vortex finder could be achieved between 3 bars to 5 bars using 4.5mm spigot opening. The diatomite is also found to be suitable for various applications such as filter, filter aid, insulation, painting and coating, cement, paper, fertilizer, rubber, plastic and a catalyst.

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