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# Quality Assessment of Sand as Silicon Dioxide Collected from the Sudanese Areas (Bara, Elmtama and Karema) for Glass Industry

Mohamed AlzuabirAlmaleeh<sup>1</sup>, Mohamed Ezeldin<sup>1, \*</sup>, Said Milad<sup>2</sup>

<sup>1</sup>Department of Chemistry, Faculty of Science and Technology, Omdurman Islamic University, Khartoum, Sudan

<sup>2</sup>Faculty of Veterinary Medicine, Zaytouna University, Tarhona, Libya

## Email address:

Wadalmsna3.com@gmail.com (M. Ezeldin)

\*Corresponding author

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**Abstract:** The silicon dioxide and microcline, samples were collected from the North Kordofan state Bara area, River Nile state Elmatama area and Karema. Then samples were subjected to X-ray diffractometer "XRD" according to standard test methods. Elements composition was characterized for all samples by X-ray fluorescence spectrometer "XRF". The particles size was carried out using sieve standards. Samples were acidified to improve the quality of silica. Silicon dioxide of Bara sand was found to be 100%, while that of Elmtama was 96.6% silicon dioxide and 3.4% microcline sand and for Karima sand 94% silicon dioxide and 6% microcline. The percentages of the silica sand were found to be 95.8% for Bara, 90.9% for Elmtama and 84.2% for Karema. The iron oxide percentage for Bara was found 0.03%. The particle size for Bara, Karema and Elmtama were found to be (60, 100, 140µm), respectively.

**Keywords:** Silica, XRD, Microcline, Glass Industry

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## 1. Introduction

Sudan has been gifted with a land having great economic natural products, and minerals. Crystalline silicon remains the principal material for photovoltaic technology. In spite of the innovations awaited in thin films technology, one considers that in 2030, mass-produced crystalline silicon will account for 80% of the produced silicon solar cells. Therefore the incessant growth in the photovoltaic industry imposes a more significant production of solar grade silicon (SGS) with improved quality [1, 2].

The production of silicon by the thermal reduction of silica with carbon is an industrial process used since the beginning of the 20th century [3, 4, 5]. The silicon produced using this method contains many undesirable impurities. Various techniques were developed about thirty years ago to purify silicon [6-10]. These techniques are very

expensive and generally cause important losses of material. To avoid those losses, to reduce the cost of the final product and to improve the purity of silicon to acceptable levels needed by photovoltaic application, one can try to purify silica using low cost techniques contributing effectively to the reduction of the final cost. Several works were carried out in this field using various techniques. Among these techniques one can cite mainly: The application of power ultrasound to the surface cleaning of silica [11], acid leaching [12, 13] and reverse flotation technique [14].

The importance of this topic was conducted this research in order to illustrate the importance of quartz and specifications and analysis for the purpose of the development of the glass industry in Sudan country.

## 2. Materials and Methods

### 2.1. Materials

All chemicals used were of analytical reagent grade (AR): Hydrochloric acid, Deionized water and sugar powder.

### 2.2. Instrumentation

X-ray diffractometer (XRD)

Model: X-ray diffractometric analytical, serial No 20029001, was used to identify of sand samples.

X-ray Florecence (XRF)

Model: PNANALYTICAL, HOLLADAAXIOX MIX 4.1 KW, was used to determine the elements composition in all samples.

### 2.3. Procedures

Samples Collection

The samples were collected from the north kordofan state Bara area, River Nile state Elmatama area and karema, Sudan.

Particle Size analysis:

Dry sieving method was adopted and the represented silica sand samples were first oven dried, 20g were placed in sieve standard, and then was shaken by hand for 5 minutes.

After saving samples they were emptied onto sheets of paper and weighted one after other and then the cumulative percentage by weight of the particles passing each sieve was calculated and recorded.

Silica Purification

Samples taken from 1g and put in different flasks (250cm<sup>3</sup>)

then add slowly on the edge of the wall hydrochloric acid 15ml by center through measuring cylinder with stirring by glass rode. preheat the beaker which covered in water bath for half an hour while continuing stirring then eased solution by adding 50ml of hot water and the solution was nominated in with suppressing glass using paper with size 12cm scarce ash after washing, the precipitate twice diluted hydrochloric acid hot (1:7) again with distilled water until the filtrate becomes free of Chloride ion and put the filter paper containing silica crucible porcelain piece of information in the weight inside the furna for an hour at temperature of 90°C then the percentage of silicon dioxide was calculated.

## 3. Results and Discussion

Sieve analysis

A 20g of samples was subjected to sieve analysis using sieve device type 60 (0.250) mm, 100(0.15)mm, 140(0.105)mm. The results were shown in table 1.

Table 1. Sieving Analysis of Raw Silica Samples.

Sample	%by weight	Properties
Karema	Nil	Medium
Elmtama	50	Fine
Bara	5	Very fine

X-ray diffractometer:

The XRD pattern of white sand showed the presence of large amount of highly crystalline quartz form of silica 100% Silicon dioxide. (Figure 1).

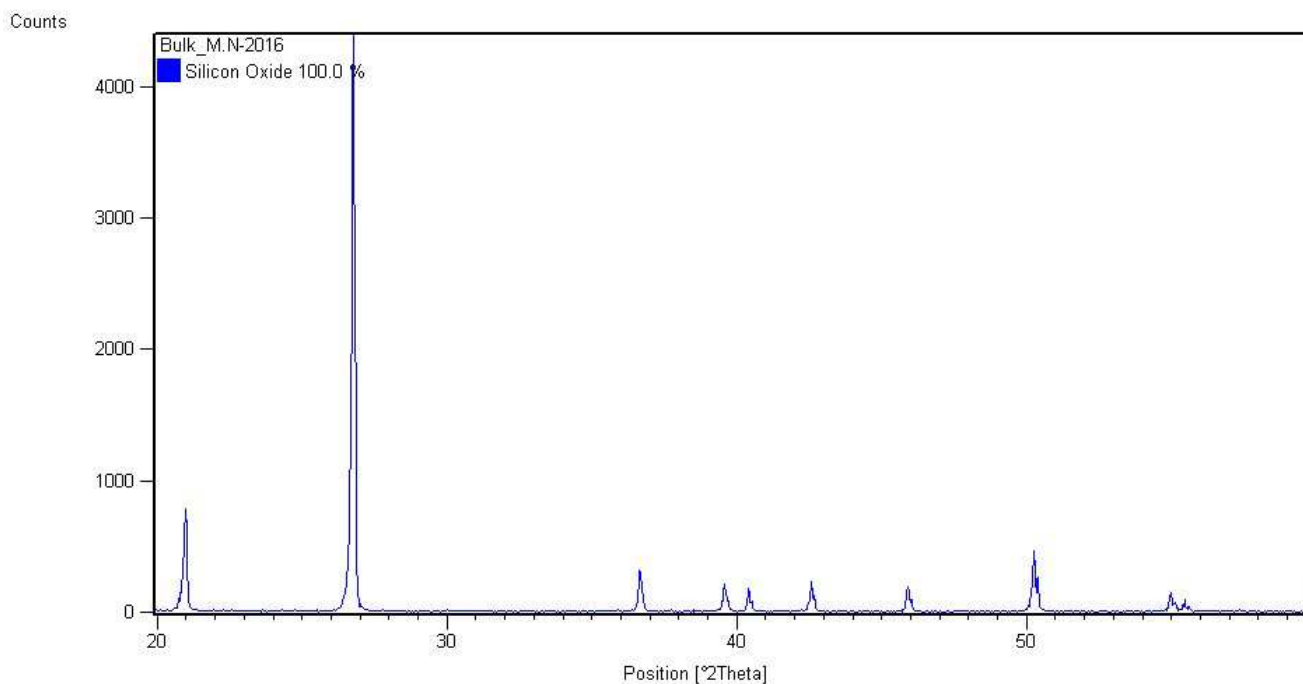


Figure 1. The XRD Pattern of White Sand Showed the Presence of Large Amount of Highly Crystalline Quartz Silicon Dioxide 96.6% and Microcline 3.4%.

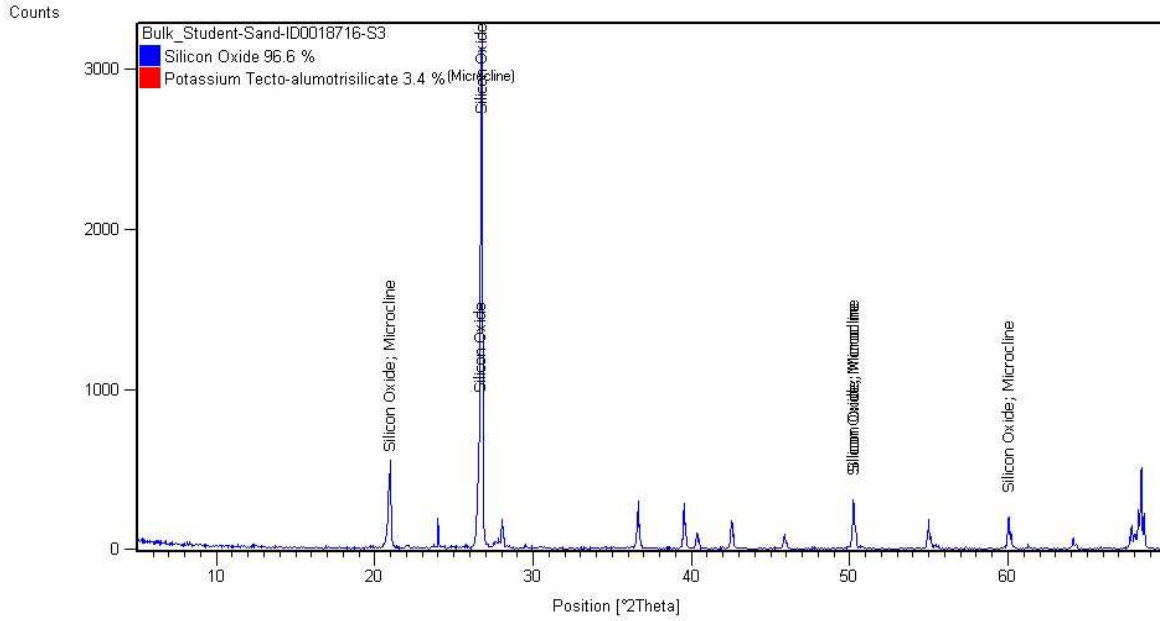


Figure 2. XRD Pattern of Elmtama Sand.

The XRD pattern of white sand showed the presence of large amount of highly crystalline quartz form of silica 94% and 6% microcline for Karima sand (Figure 3).

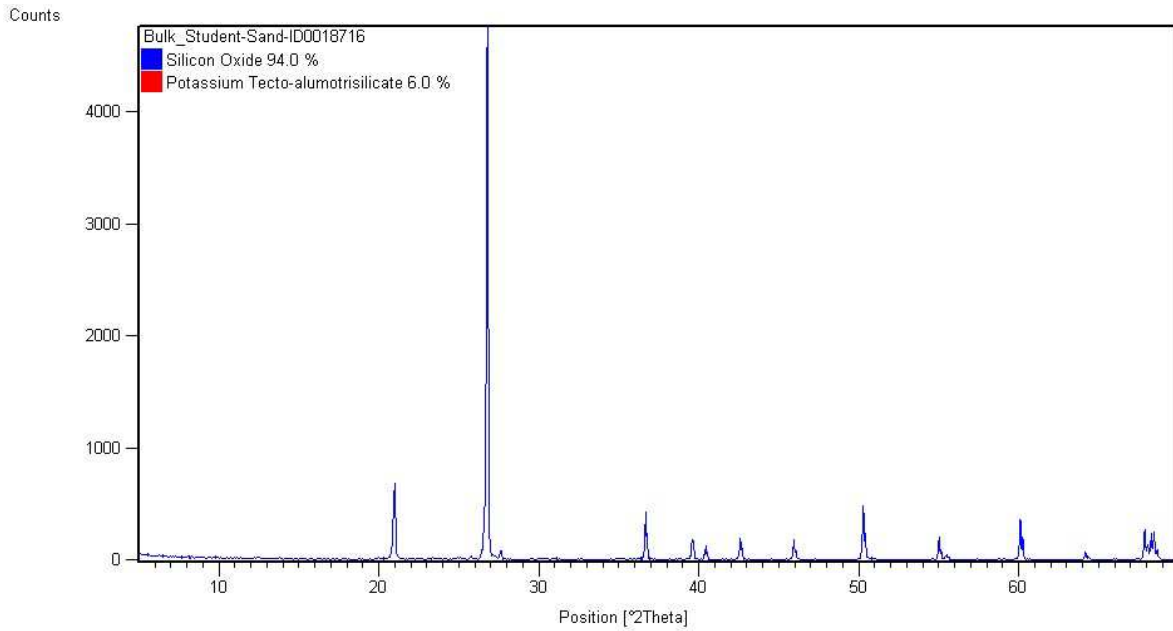


Figure 3. XRD Pattern of Karima Sand.

X-ray Fluorances:

The main ingredient for glass making is the silicon oxide and it varies based on the type of glass to be made. The results in Table (1) show the chemical contents analyzed for the silica sand samples obtained from three different areas. The percentages of the silica sand are 95.8% for Bara, 90.9% for Elm tama and 84.2% for Karema. Which are high for glass making compared by Indian specification standard, however the percentage of iron oxide obtained 0.3 for Bara and 0.4 for Elm tama and 2.17 for Karema. The percentage of Al<sub>2</sub>O<sub>3</sub> was show high in Karema sand resulting in reduced

ratio of SiO<sub>2</sub> The percentage of the entire min ingredient [MgO, CaO] obtainable in the silica sand samples as shown in Table [1] were very low however the two samples Bara and Elmtama can be used for colored container glass and glass for insulating fibers. Karema sand can be used in colored and amber glass production, since the chemical compositions were obtained as K<sub>2</sub>O 0.04%, 0.88%, 0.703%. Na<sub>2</sub>O 0.021%, 0.121%, 0.839% for Bara, Elm tama and Karema respectively. Which fall within the range of [2-9]% by weight of K<sub>2</sub>O and Na<sub>2</sub>O.

**Table 2.** The Chemical Compositions of Silica Sand Samples.

Chemical Composition	Bara Sand%	Elmatama Sand%	Karema Sand%
Na <sub>2</sub> O	0.021	0.121	0.839
MgO	0.259	0.2	1.085
Al <sub>2</sub> O <sub>3</sub>	2.871	6.382	8.438
SiO <sub>2</sub>	95.844	90.901	84.27
P <sub>2</sub> O <sub>5</sub>	0.02	0.019	0.157
SO <sub>3</sub>	0.019	0.134	0.076
Cl	0.007	0.017	0.056
K <sub>2</sub> O	0.041	0.884	0.703
CaO	0.028	0.158	1.422
TiO <sub>2</sub>	0.488	0.442	0.647
Cr <sub>2</sub> O <sub>3</sub>	0.013	0.029	0.029
MnO	0.008	0.005	0.031
Fe <sub>2</sub> O <sub>3</sub>	0.312	0.436	2.174
NiO	0.005	0.116	0.005
CuO	0.005	0.067	---
ZnO	0.007	0.001	0.004
Y <sub>2</sub> O <sub>3</sub>	0.001	0.001	0.002
ZrO <sub>2</sub>	0.057	0.032	0.042
SrO	---	0.007	0.014
BaO	---	0.023	0.023

Chemical Composition	Bara Sand%	Elmatama Sand%	Karema Sand%
CeO <sub>2</sub>	---	0.023	---
Rb <sub>2</sub> O	---	0.002	0.002

#### Purification of Silica

Purification sand by acids to improve the quality of the silica for glass produced after treatment with Hydrochloric acid concentrated, then was burned. Silica rate increased, so reducing the content of impurities which shown in Table 3.

**Table 3.** Purification of Samples.

Sand samples	Before purification	After purification
Bara	95.8% as SiO <sub>2</sub>	97.7% as SiO <sub>2</sub>
Elmtama	90.9% as SiO <sub>2</sub>	93.8% as SiO <sub>2</sub>
Karima	84.2% as SiO <sub>2</sub>	86.2% as SiO <sub>2</sub>

The percentage values of silica in Bara sand within the minimum standard (grade 3) in Indian standard (97.7%).

**Table 4.** Indian Standard Specifications for Glass Making Sands – 2<sup>nd</sup> Revisions [IS 488: 1980].

No	Characteristics by% mass	Requirement			
		Grade III	Grade II	Grade I	Special Grade
1	Loss on ignition Max.	0.5	0.5	0.5	0.5
2	Silica( asSiO <sub>2</sub> ) Min.	97	98	98.5	99
3	Iron oxide( as Fe <sub>2</sub> O <sub>3</sub> )	0.1	0.06	0.04	0.02
4	Aluminum oxide as (Al <sub>2</sub> O <sub>3</sub> ) Max.	*	*	*	*
5	Titanium oxide as (TiO <sub>2</sub> ) Max.	*	0.1	0.1	0.1
6	Manganese oxide as (MnO)	To pass the test	To pass the test	To pass the test	To pass the test
7	Copper oxide as (CuO)	To pass the test	To pass the test	To pass the test	To pass the test
8	Chromium trioxide as(Cr <sub>2</sub> O <sub>3</sub> )	To pass the test	To pass the test	To pass the test	To pass the test

\*These requirements shall be as agreed between the purchaser and the supplier.

Special Grade: for manufacture making glass, Grade I: for manufacture g glass container, Grade II: for manufacture glass container with slight tint, and Grade III: for manufacture colored glass.

**Table 5.** Size Grade.

Size grading	wt.%
Retained on 1 mm IS sieve	Nil
Retained on 600 micron IS sieve% by mass Max.	1
Retained on 600 micron IS sieve% by mass. Max.	
Passing through 600 micron IS sieve but retained on 300 micron IS sieve% by mass Max.	50
Passing through 300 micron IS sieve but retained on 125 micron IS sieve% by mass Max.	50
Passing through 125 micron IS sieve% by mass Max.	50

## 4. Conclusion

In conclusion, bara sand represent the best content of silica.

The purification process has been increased the percentage of SiO<sub>2</sub> from 95.8% to 97.7% that met the Indian standard specification for the manufacture of glass. TiO<sub>2</sub> was found to 0.4% in Bara sand its needs process to reduce the percentage by another process. The percentages of silica content 90.9% for Elmatam sand and 84.2% for Karima sand needs more purification to increase the percentage of SiO<sub>2</sub>.

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