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EXPOSITION ON SILICA SAND RESERVES IN NIGERIA AND ITS IMPACT ON METALLURGICAL INDUSTRIES

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ABSTRACT

Silica (SiO₂) as sand is one of the mineral raw materials that occur extensively in nature. It is a mineral that is associated with free flowing forms as dust and sand and is known in consolidated forms as crystals, quartz, pebbles and stones. Silica Sand is also found in large deposits in Nigeria as components of rock forming minerals. These Silica Sand deposits have appropriate grain size distributions and high degree of purity. The sand deposits are used for various applications such as abrasives, glass making, chemical production, building construction, paints and coatings, water filtration, ceramics and refractories, oil and gas recovery, recreational activities and other purposes. Silica Sand impacts every aspect of our daily living. Although, Silica Sand is a non-toxic material with no known toxic effect on ingestion, it poses considerable health hazards with respect to long-term inhalation as dust. This paper therefore aims at exploring the chemistry of Silica Sand resources for commercial use in metallurgical industries, paint/coating formulations for improved aesthetics on metallic substrates and its relevance to national development.

Key Words: Silica Sand, Applications, Impacts and Relevance.

1. INTRODUCTION

Silica as sand is a versatile raw material used for various industrial purposes. The initial industrial uses of the sand were as old as man in the metallurgical and glass-making industries (Batelco, 2007). It is the source of silicon used for ferrosilicon production, a component of alloy steel (Kamar, 2004). Metallurgical flux, alumina silicate (Popular Science, 2005), silicon carbide and synthetic foundry molding sands contain Silica Sand that confers varying properties to the different products. Silica Sand serves as a filler material in the composition of refractory bricks. From the beginning of the traditional use of Silica Sand in the glass, refractory, and metallurgical industries, the endowment of Silica Sand industrial development has persisted with its transformation to silicone and siloxane derivatives. This is a network with a backbone of alternating silicon and oxygen atoms (-Si-O-Si-O-). This interconnection can be easily extended to a very long chain, modified to branched or cross-linked structures exhibit varied physical and chemical functionalities. These properties facilitate the invention of silicone-based products made to provide varying features for numerous applications (Chukwu *et al.*, 2012). Currently, among other uses of Silica Sand is the contribution to information technology revolution. It supplies the raw material for silicon chips that form the basis of modern electronics and computers (Ratson, 2007). Similarly, recent studies have evaluated the use of Silica Sand as a constituent of solar cells. The awareness of the huge deposits of silica as sand resource in Nigeria and its industrial potentials have long been created by Raw Materials Research and Development Centre

(RMRDC) (IbrahimBiliaminu, 2010), Nigerian Mining Cooperation (NMC) and other government agencies. However, despite the availability of huge deposits of Silica Sand in the country, very little use is made of the sand except for the traditional uses in glass and refractory products. In spite of this, the quality of the glass and ceramic products made locally do not compete favorably with the imported products.

Furthermore, refractory bricks, ferrosilicon, abrasives, high quality foundry sands etc. are imported into the country despite the abundance of the raw material (RMRDC, 2010). These facts are quite challenging. This paper therefore presents a comprehensive use guide for Silica Sand resource. The studies on the use of Nigerian Silica Sand for various applications are reported and the factors responsible for its low utilization listed.

2. 1 Silica Sand Formation

Silica referred herein as sand grains are entirely quartz, resulting from weathering /erosion of rocks and transportation by rivers and/or the sea. It is a sedimentary material categorized as loose grains leached out from decomposed and disintegrated rocks. The sand from this source has fine granules with grain size ranging between 0.06 and 2.0mm in diameter. However, a grain of Silica Sand is either round or angular in shape, white, milky or brown in colour and hard, measuring seven on Mohrs scale. Naturally occurring Silica Sand contains some undesirable impurities like clay kaolinite, titanium, iron oxides and heavy elemental oxides. The term ‘Silica Sand’ is used to identify sand that conforms with the specifications of main composition of about 95% SiO₂ with impurity less than 5% (Sara *et al.*, 2003).

2.2 Silica Sand Deposits in Nigeria

Available records have shown that Nigeria is blessed with abundant Silica Sand resource (RMRDC, 2009). Table 1 shows Silica Sand deposits in Nigeria that can be used in the production of goods in their primary forms (and processed forms) as essential input raw materials for a host of other industrial products. Many of the Nigerian Silica Sands are associated with the coastal plain of sedimentary areas of the southern parts of the country. However, few deposits of the sand occur in the northern regions of the country. It is important to note that these deposits occur in significant quantities in the country (Mines Department, 1993).

Table 1: Silica Sand Resources in Nigeria

S/N	STATE	LOCATION
1	Abia	Ukwa, Aba, IsialaNgwa, Azumili
2	AkwaIbom	Ikwo, Ukem, Ibeno
3	Anambra	Onitsha, Costal Area of Ulasí River
4	Bayelsa	Sagbama, Ijaw,
5	Benue	Buruku, Gboko, Guma, Kast
6	Bornu	Dikwa, Gwoza, Jere
7	Cross River	Ikom, Mfamosing
8	Delta	Ughelli, Aniocha, Burutu, Ethiope
9	Enugu	Enugu, Ekulu, Igbo Eze, Udi
10	Gombe	Yamaltu-Deba, Dukku
11	Imo	Ihiagwa, Obinze, Isu, Njaba

12	Jigawa	Kangama, Kasaure
13	Kaduna	Kaduna
14	Kano	Dambatta, Makoda
15	Kastina	Zango
16	Lagos	Apapa, Badagry, Epe, Lekki
17	Nasarawa	Lafia, Doma, Nasarawa
18	Niger	Gbako, Gurara, Mokwa, Bida
19	Ondo	Ogun waterside, Obafemi
10	Ogun	Igbokada, Akata, Agbala
21	Rivers	Etche, Obio, Okirika, Oyigbo
22	Sokoto	Sabo, BiriniWamako
23	Taraba	Jalilingo, Bali, Takum
24	Yobe	Ngeji, Fita, Damaturu, Nguru, Tarmuwa
25	Zamfara	Jamuri, Gumi

Source: RMRDC Technical Publications020 (2010)

2.3 Silica Sand Use Guide

Silica Sand can be used in the raw form in the manufacturing of some products or processed form for transformation into intermediate feedstock for new materials production. Table 2 is an illustration of allied industries and products that receive stimulus from the use of Silica Sand. Silica sand is used mainly in metallurgical industries as abrasive, molding sand, refractory and fluxing agent (Table 3)

Silica Sand Form	Property Applied	Products
Silica Sand Particle Size (BS Mesh 200) 75 μ	Hardness, Sharp, and Crystalline Nature	Abrasives: Liquid Polishes for Metals, Car Bodies, Buffing Compounds in Grease Scouring and Cleaning Powder, Insecticide
	Acid and Temperature Resistant	Explosives, Acid Resistant Cements Battery Casing (Plastics), Rubber Filler, Specialized Bitumen and Paints
	Thermal Expansion	Ceramic and Refractory
	Regulation Drying and Shrinkage. Structural Integrity, Appearance	Porcelain, Glazes, Enamels, Fillers for Refractory Bricks
	Provides Density and Strength, Extender, Corrosion and Weather Resistant	Building Materials, Insulating Roofing Materials, Cements Foamed Concrete
	Heat Resistance	Impacts Hot and Dry Strength to Foundry
Graded Sand	Hardness, Sharp, and Crystalline Nature	Abrasive Cloth and Paper

Table 2: Silica Sand Use Guide

Fine Sand	Ability to Reduce The Sand to Si Metal, A Precursor to Other Chemical Processes	Chemical Production of Sodium Silicate, Silicones and Ferrosilicon
Medium Sand	Drying and Shrinkage, Integrity, Appearance	Foundry Molding Sand
	Transparent and Translucent, Strength and Purity	All Types of Glass
Coarse Sand	Grain Size Distribution, Provides Filtration Beds	Water Purification
	Aeration and Porosity for Golf Court	Golf Court

Some of the Uses of Silica Sand in the Metallurgical Industries**Table 3: Some Metallurgical Uses Of Silica Sand**

Silica Sand Form	Product	Application	Sand requirement and properties
Abrasive	Silicon Carbides	Cutting tools	Quartz Content Silica (75%-95%) Free from Clay and Coating Impurities
	Abrasive Grits	Cleaning	
Metallurgical	Alumina Silicates	Alloy Steel	Lower Melting Point of Base Metal. High Quality Silica Sand Required with Very Low Level of Impurity Because SiO ₂ is the Active Ingredient of the Reaction Process
	Ferrosilicon		
	Foundry Sands	Casting Sands	Requires Uniformly Sized Rounded Silica Grains, Ensuring Evenly Coating of the Bonding Material. But Synthetic Bonded Sand are more trendy offering dependable and controllable molding properties
Refractory	Refractory Bricks		Requirement Sand with SiO ₂ Content (95%-98%). The use of Silica Bricks in the Steel Industry is fast losing grounds because of the gradual change in the practice of manufacturing steel by Basic Furnace

3. Silica Sand in Paint, Coating and Metallurgical Industries

Paint formulators select micron sized Silica Sand to improve the appearance and durability of architectural/industrial paints and coatings. High purity Silica Sand contributes critical performance properties such as brightness and reflectance, colour consistency and oil absorption in industrial paints. In architectural paints, Silica Sand fillers improve tint retention, durability and are resistant to dirt, cracking and weathering. In marine and maintenance coatings, the durability of Silica Sand impacts excellent abrasion and corrosion resistance. It is worthy to note that silica sand flour used by paint manufacturers are imported into the country with the trade name ‘marble dust’.

Enamel coating is a form of glass coating on metal. Enamel coatings are formulated by melting

varying compositions of Silica Sand and other chemical compounds and fused on a metal substrate. The coating confers on the metal protection from various adverse effects and enhances its aesthetic values. Nigerian Silica Sand has been successfully utilized in the production of enamel coating materials (frits) (Chukwu *et al.*, 2002). Enamel frits are still imported into the country today due to lack of infrastructural facilities required to establish a production unit.

Extensive work has been done on the adaptation of Opa Silica Sand in Ile Ife as mold sand for foundries. Opa sand was used to produce molding sand with optimum mold performance on effective mixture with some additives (Atanda *et al.*, 2011).

The suitability of five (5) local Nigerian sands for gravel packing in oil/gas wells have been assessed. It was found that only washing and processing of the sand is needed to improve the quality of the sands to acceptable standard (Nforet *et al.*, 2012). It has also been reported that silicon has been successfully extracted from Zauma (Zamfara) river sand (Idrisa *et al.*, 2013). As laudable and commendable as these projects are, they are isolated and have not been transferred from the laboratory scale to the pilot scale.

Factors Militating Against The Development of Silica Sand Industries

This is characterized by the lack of essential inputs to a viable technological base mainly;

- Good infrastructure with cheap and uninterrupted power supply
- Quality education and technological culture
- Lack of processed raw materials
- Adequate funding by the government of Research and Development (R & D) programmes and commercialization of R & D results. The challenge now is on how to move forward. This calls for joint partnership participation with the government in order to address the problems enumerated above. This may not be an easy task but a start, and a sustained development of the above projects is the only available option

4. CONCLUSION

Silica (SiO_2) consists of the two most abundant elements on earth, silicon and oxygen. It exists in different forms namely flour, sand, and rock. Silica Sand is hard, chemically inert with high melting point. These are prized qualities in applications like foundry, chemical production, water purification, paints coatings etc. Available data have shown that Nigeria is blessed with huge reserves of Silica Sand deposits and more to be explored and exploited. It is therefore recommended that the Public and Private Sectors should collaborate to address the low capacity utilization of this abundant mineral resource

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