

Material Development of Nano Silica Indonesia for Concrete Mix

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Abstract. Based on data from Indonesian Directorate General of Mineral and Coal Technology, popular sources of silica sand in Indonesia can be found: Bangka Belitung, Pangkal Pinang, South Sumatra, Lampung, West Kalimantan, South Kalimantan, West Java, and East Java. Unfortunately, the use of silica sand in concrete mix is still limited as filler material. The challenge is then to explore the use of such silica sand, for instance in the form of nano silica. This research work explores silica sand from: Bangka Belitung, Pangkal Pinang, Lampung, West Java, East Java, West Kalimantan and South Kalimantan. The selected silica sand are then processed by the novel method developed by Indonesia Center for Ceramics using Polishing Liquid Milling Technology. The result is expected to contribute in the development of increased added value of locally available silica sand and to advancing application of nano silica for concrete.

Introduction

Indonesia offers some potentials to participate in the era of nanotechnology. Its vast natural resources such as petroleum, metal, minerals, coal and other natural materials are available for further explorations. Unfortunately, Indonesia is more famous for providing raw materials has not been processed into a mainstay commodity. Increased economic value of natural resources can be made through nanotechnology. With the development of nanotechnology natural wealth management process is no longer limited to generating some added values, but also to value creation. Silica sand is commonly used among others as a filler in mixtures of concrete and mortar. This gives the opportunity and motivation to perform further research to produce nano silica originating from Indonesia's natural resources to be applied on cement mortar and concrete. Creation of value can be accomplished through processing of natural silica to become nano silica. Silica sand are chosen from locations famous for silica reserves and quarries such as Bangka Belitung, Pangkal Pinang, Lampung, West Java, East Java, South Kalimantan and West Kalimantan. Among of the main steps in using silica sand for concrete are screening suitable material, process the raw silica sand into finer powder, thereby improving its chance to act also as pozzolan, and developing the engineered mix proportion. In this work, silica sand from various locations are evaluated in terms of chemical composition and particle size. The sand are subjected to the so called Polishing Liquid Milling Technology developed in Center for Ceramics, Indonesia. The objective is to determine whether the processing technology is suitable allowing producing nano silica from the selected silica sand.

Literature References

Recent researches on the use of nano silica in mortar and concrete indicated a trend of improved and enhanced performance of mortar and concrete [1, 4].

Silicon Dioxide (SiO₂) is often used in concrete mixtures to increase strength and reduce permeability [3]. There are two reason to use of SiO₂ in mixture of concrete, the first chemical interaction between silicon dioxide and calcium hydroxide released during cement hydration process, the second is due to an increase in mechanical continuity of distribution of fine particles of silicon dioxide into the substance of the matrix [3].

Methodology

Silica sand were obtained from : Bangka Belitung, Pangkal Pinang, Lampung, West Java, East Java, South Kalimantan, and West Kalimantan. Then the silica sand is done through testing screening with *X-Ray Fluorescence* (XRF), *Scanning Electron Miscroscope* (SEM) *X-Ray Diffraction* (XRD) and testing with *Particle Sizer Analyzer* (PSA), XRF result can be seen in Table 1.

Tabel 1 XRF Method Chemistry Analysis Result

Source of silica sand	Oxides in %				
	SiO ₂	TiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO
Bangka Belitung	99.24	0.0747	0.143	0.107	0.0302
Pangkal Pinang	61.65	0.316	1.22	0.977	22.45
Lampung	92.30	0.441	2.48	2.57	0.196
West Java 1	67.48	1.05	15.58	4.42	2.37
West Java 2	72.98	0.851	13.48	3.74	2.42
East Java 1	93.42	0.231	2.12	1.14	1.13
East Java 2	91.47	0.163	3.68	2.07	0.186
South Kalimantan	95.40	0.172	2.65	0.740	0.0403
West Kalimantan	99.55	0.0501	0.0513	0.0352	0.0107

Bangka Belitung silica sand chosen for further processing into nanosilica Indonesia using Polishing Liquid Milling Technology (PLMT) . PLMT is a method developed a process to produce nanopowder from Indonesia Center of Ceramics, as shown in Figure 1.

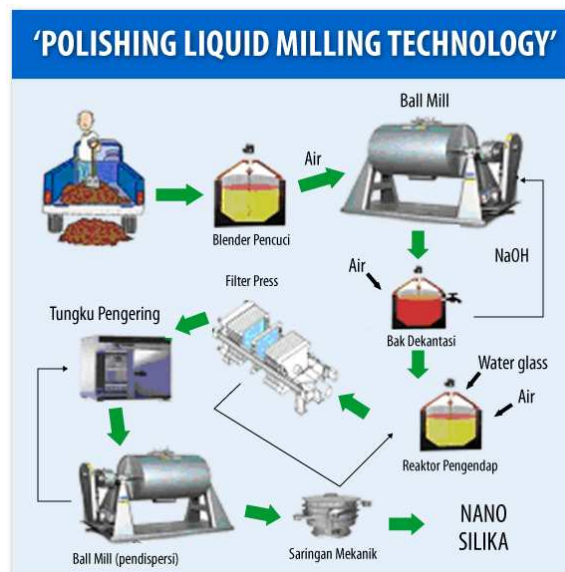


Fig.1 Flow Diagram of Nanosilica Synthesis [Courtesy of Center for Ceramics]

According to the schematic description of the technology, the raw material is first blended and washed before being ball milled for a period of time. Then silica sand is separated, filtered, and oven-dried. What is somewhat unique is that prior to being separated the sand is sedimented in a reactor. The next step is ball milling for the second time to allow dispersion followed by sieving to obtain the nano size particles or nanosilica. The produced nano silica is tested for characterization using PSA, SEM, XRD, and XRF-EDS. The produced nanosilica is then compared with commercially available nano silica, namely Jiangsu and Aerosil HDKN 20.

Result and Discussions

Produced nano silica has been analysed for particle size distribution using the particle size analyser. The result shows that nano silica Indonesia has more than 50% particles of measuring 70 nm as shown in Figure 2, visual characterization using SEM having 60,000 x magnification, some particles are in fact larger than 100 nm, as confirmed by SEM. The result of XRF in Table 2. simply suggests that the produced nanosilica contains 99.60% SiO₂. Meanwhile, Jianguo nano silica contains 99.94% SiO₂ and Aerosil HDKN 20 contains 99.99% SiO₂. XRD result as is given in Figure 3. It shows that nano silica Indonesia, Jianguo and Aerosil nano silica HDKN 20 are amorphous silica particles.

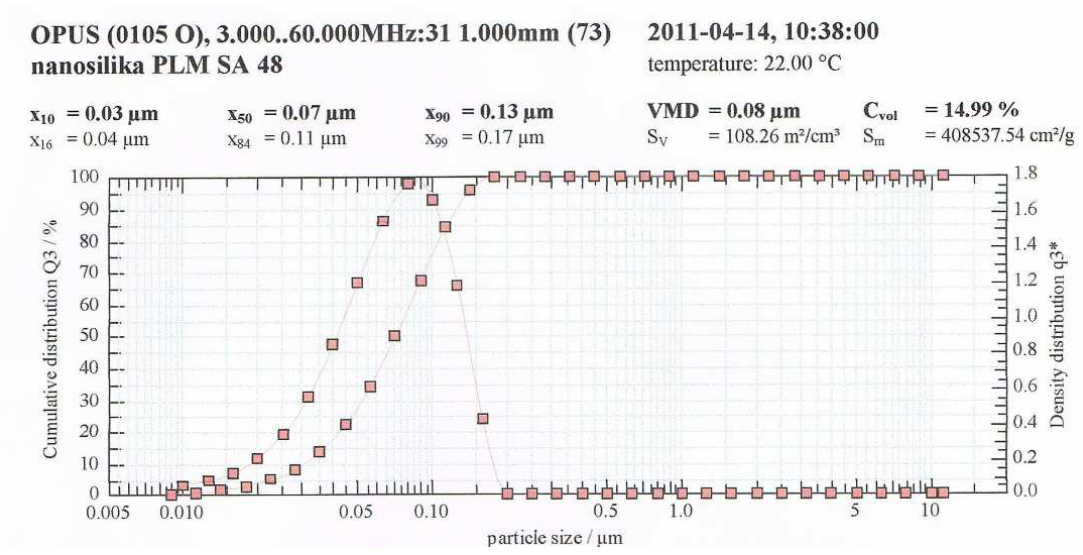


Fig.2 PSA of Nano silica Indonesia

Table 2 Test result of nano silica [in weight percent]

Oxides in %	Type of Nano silica		
	NS Jianguo	Aerosil	NS Indonesia
Na ₂ O	-	-	-
Al ₂ O ₃	-	-	-
SiO ₂	99.94	99.99	99.60
S	-	-	-
ZnO	0.02	-	-
TiO ₂	0.04	-	-
CuO	-	0.01	-
BaO	-	-	0.32
Fe ₂ O ₃	-	-	0.08

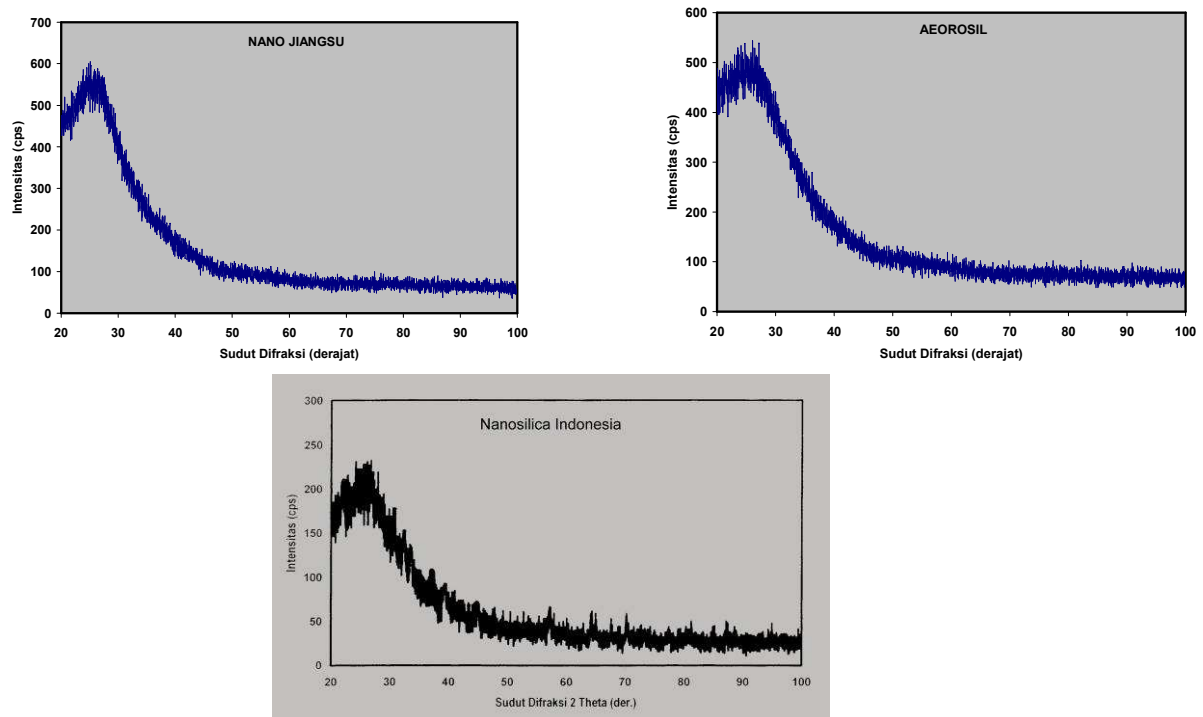


Fig.3 XRD Pattern of Nano silica Jianguo, Aerosil HDKN 20 and Nano silica Indonesia

Summary

Development of Indonesia nano silica using Polishing Liquid Milling Technology has succeeded in producing nano silica to produce an equivalent with nano silica marketed in commercial scale. Nano silica Indonesia needs further treatment, among other the content of SiO₂ purification process, and process to produce large amounts of nano silica particles with size of less 100 nm.

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