Extraction Of Silica Dioxide (SiO\textsubscript{2}) From Mount Sinabung Volcanic Ash with Coprecipitation Method

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Abstract. Mount Sinabung volcanic ash is a basic material that can be used to produce silicon dioxide (SiO\textsubscript{2}). SiO\textsubscript{2} can be used as a building raw material as well as in food and beverage packaging. To produce SiO\textsubscript{2}, the volcanic ash of Mount Sinabung must be synthesized using the coprecipitation method. The result of this process produces SiO\textsubscript{2} content as much as 48\%, a formed function group that states the existence of SiO\textsubscript{2} namely Si-O-Si and Si-O at absorption of 1095.57 cm\textsuperscript{-1} and 798.53 cm\textsuperscript{-1}. From the results of SEM can be seen the morphology of SiO\textsubscript{2} formed. In the XRD results, the phase of SiO\textsubscript{2} is amorphous.

1. Introduction

Indonesia is an archipelago which is crossed by the equator and located between the continents of Asia and Australia and between the Pacific Ocean and the Indian Ocean. It is surrounded by the Eurasian, the Indo-Australian and the Pacific plate. In addition, this region is also the path of the Pacific Ring of Fire (Ring of Fire), which is a series of lines of active volcanoes in the world[1]. Mount Sinabung, which is called Deleng Sinabung in Karonese, one of active volcanoes in Indonesia. Located in the province of North Sumatra with coordinates the summit of Mount Sinabung is 03\degree 10' N and 98\degree 23' E with the highest peak 2,460 meters above sea level the highest peak in North Sumatra[2][3]. Mount Sinabung eruption increased to the level of 4 (Alert) on November 24, 2013 since it spat out black, thick smokescreen, followed by sand rain and volcanic ash which covered thousands of hectares of farmers’ crops under the radius of six kilometers so that more than 20 thousand people had to be evacuated[4].

The abundance of volcanic ash material as a result of the eruption of Mount Sinabung is an interesting thing to study. According to tests that have been done using Spektroskopif Serapan Atom (Atomic Absorption Spectrophotometry – AAS) showed that the volcanic ash from Mount Sinabung contains 78,3\% SiO\textsubscript{2}, 2,91\% Fe\textsubscript{2}O\textsubscript{3}, 4,56\% Al\textsubscript{2}O\textsubscript{3}, 1,07\% MgO, 4,84\% CaO, and 0,46\% Na\textsubscript{2}O[5]. SiO\textsubscript{2} is one of the most abundant compound in the Volcanic Ash Sinabung has the potential to be used a variety of needs[6]. One of the ways used to obtain high-purity SiO\textsubscript{2} can be obtained by synthesis of SiO\textsubscript{2}-based nature with relatively high Si element content using coprecipitation method. The
coprecipitation (deposition) method is a type of fabrication technique using a chemical method that brings a solute downward to form the desired precipitate[7][8][9].

Research that has been done using volcanic ash material, namely extraction volcanic ash of sinabung mount silica to production silica gel. This research tries extraction volcanic ash of sinabung mount with sol-gel method[10].

2. Methods

In this study, the manufacture of extraction silica dioxide (SiO$_2$) using Volcanic ash of Sinabung mount, Chloride acid (HCl) 2 M, distilled water, Natrium Chloride and Natrium Hidroxide (NaOH) 7M. This research using coprecipitation method.

Mount Sinabung volcanic ash was sieved with a 200 mesh filter. Put it in a container of 300 grams of Mount Sinabung volcanic ash that has been sifted. Add HCl 2 M with a ratio (1:10) and stirred for 12 hours. Settling for one night until the ash settles, the precipitate was washed with distilled water until pH = 7. Add 7 M NaOH (1:10); Then heated at a temperature of 100-130°C while in stirrer for 24 h. After reaction was complete, allowed to stand to separate. Furthermore, the filtrate is filtered with a paper filter Results whattman No. 42 in tittrasi with 2 M HCl until pH neutral. Settling up a separate deposition. Dried sludge by using an oven at 70-80°C to dry. Precipitated silica dioxide obtained weighing 68.58 grams of 300 grams of volcanic ash Mount Sinabung.

3. Results and Discussion

3.1 XRF analysis of SiO$_2$ from Sinabung Volcanic Ash

The Mount Sinabung volcanic ash content has been extracted through the coprecipitation process can be seen in table 1. Based on the results of XRF shows the content of SiO$_2$ compounds as much as 48%, the content of elements Si 26.9 %, and the content of elements Cl 22.8 %. From the test results showed the content of SiO$_2$ has a fairly high content. It can also be observed with discoloration occurring. The Mount Sinabung volcanic ash color is gray, after the coprecipitation process turns white[11].

| Composition | Percentage (%) |
|-------------|----------------|
| SiO$_2$     | 48             |
| Si          | 26.9           |
| Cl          | 22.8           |
| P$_2$O$_5$  | 0.5            |
| K$_2$O      | 0.17           |
| CaO         | 0.66           |
| Cr$_2$O$_3$ | 0.058          |
| Fe$_2$O$_3$ | 0.61           |
| BaO         | 0.28           |

SiO$_2$ content can be used in the field of industry, among others cement industry, ceramic industry, ferosilicone manufacturing industry. SiO$_2$ can not stand alone so it must bind to oxygen to form a compound that is silicon dioxide compound (SiO$_2$). So if the oxide level is getting smaller then it is expected that SiO$_2$ levels will be greater anyway. This means that the purer SiO$_2$ levels, so that it can be used in various fields. Examples of food and beverage packaging such as bottles and glasses[12].

3.2 Morphology analysis of SiO$_2$ from Sinabung Volcanic Ash

SiO$_2$ morphology from Mount Sinabung volcanic ash was observed using Scanning Electron Microscope (SEM). Test results using SEM can be observed in figure 1.
In figure 1, the surface structure of SiO$_2$ is seen. SiO$_2$ shape looks like granules that appear that the surface has not seen the presence of grain boundary, with the size of pores large enough to form unevenly distributed blobs. These results indicate that SiO$_2$ has low stability[13]. Then from the results SEM seen other minerals that still cover the surface of SiO$_2$. It can also be linked to the XRF test hail which shows the still high content of Cl in the process to obtain SiO$_2$ from the Mount Sinabung volcanic ash.

3.3 FTIR Analysis
To find out the chemical bonds present in SiO$_2$ using FTIR. The FTIR test results for SiO$_2$ can be seen in figure 2. There are seven absorption tapes from the FTIR test results, the results of which are presented in table 2.

Bonds that appear on wave numbers 470.63 cm$^{-1}$, 798.53 cm$^{-1}$, 948.98 cm$^{-1}$, 1095.57 cm$^{-1}$, 1635.64 cm$^{-1}$, and 2399.45 cm$^{-1}$. The absorption band at 470.63 cm$^{-1}$ is a bond of O-Si-O from siloxy group. Absorption at 1635.64 cm$^{-1}$ and 3437.15 cm$^{-1}$ is a hydroxyl function group of-OH stretching and -OH bending [14]. At absorption 798.53 cm$^{-1}$,948.98 cm$^{-1}$ and 2399.45 cm$^{-1}$ is a hydroxyl function group of Si-O, Si-OH dan Si-C[15]. At absorption 1095.57 cm$^{-1}$ is a siloxan function group of Si-O-Si[16].
Table 2. Chemical bonding on SiO₂ from Mount Sinabung volcanic ash

| No | Bands in SiO₂          | Wavenumbers (cm⁻¹) |
|----|------------------------|--------------------|
| 1  | O-Si-O (Bending)       | 470.63             |
| 2  | Si-O (Bending)         | 798.53             |
| 3  | Si-OH (Stretching)     | 948.98             |
| 4  | Si-O-Si (Stretching)   | 1095.57            |
| 5  | -OH (Bending)          | 1635.64            |
| 6  | Si-C (Stretching)      | 2399.45            |
| 7  | -OH (Stretching)       | 3437.15            |

3.4 XRD analysis
To find out the phase on SiO₂ of volcanic ash Mount Sinabung used XRD. The XRD measurement results can be seen in figure 3. SiO₂ has this amorphous properties can be seen in 2θ = 22.16°. In addition to the formation of phases of SiO₂ formed another phase due to the coprecipitation process. The phase that appears is the phase of NaCl. This is in accordance with the XRF results that indicate the presence of C element in the SiO₂ content of Mount Sinabung volcanic ash.

![Figure 3](image)

Figure 3. XRD image of SiO₂ from the Mount Sinabung volcanic ash.

4. Conclusions
Mount Sinabung Volcanic ash can produce Silicon dioxide (SiO₂) by coprecipitation method. SiO₂ obtained from the process as much as 48 %. From the results of SEM seen SiO₂ morphology that is still sequined with other minerals. Characterization using XRD obtained phases from SiO₂ which is amorphous. The characterization that indicates the existence of SiO₂ can be seen with the formation of Si-O-Si and Si-O function groups.

References
[1] D. O. Latif, A. Rifa’i, and K. B. Suryolelono, “Chemical characteristics of volcanic ash in Indonesia for soil stabilization: Morphology and mineral content,” Int. J. GEOMATE, vol. 11, no. 4, pp. 2606–2610, 2016, doi: 10.21660/2016.26.151120.
[2] L. Simatupang and D. S.Si, “The preparation and characterization of Sinabung volcanic ash as silica based adsorbent,” J. Pendidik. Kim., vol. 8, no. 3, pp. 9–13, 2016, doi: 10.24114/jpkim.v8i3.4478.
[3] L. Simatupang, M. Situmorang, H. Marpaung, and R. Siburian, “Fabrication of silica-based chitosan biocomposite material from volcanic ash and shrimp husk by sol gel method for
adsorbent of cadmium (II) ions,” Indian J. Chem. Technol., vol. 27, no. 5, pp. 387–394, 2020.

[4] R. Karolina, Syahrizal, M. A. Putra, and T. A. Prasetyo, “Optimization of the use of volcanic ash of Mount Sinabung eruption as the substitution for fine aggregate,” Procedia Eng., vol. 125, pp. 669–674, 2015, doi: 10.1016/j.proeng.2015.11.102.

[5] H. Maulida, Ginting, M., dan Wici, “Menghasilkan Silika Gel Extraction Volcanic Ash of Sinabung Mount Silica To Production,” J. Tek. Kim. USU, vol. 6, no. 3, pp. 41–46, 2017.

[6] S. Sulastri and S. Kristianingrum, “Berbagai Macam Senyawa Silika: Sintesis, Karakterisasi dan Pemanfaatan,” Pros. Semin. Nas. Penelitian, Pendidik. dan Penerapan MIPA, pp. 211–216, 2010.

[7] L. Silvia and M. Zainuri, “Analisis Silika (SiO2) Hasil Kopresipitasi Berbasis Bahan Alam menggunakan Uji XRF dan XRD,” J. Fis. dan Apl., vol. 16, no. 1, p. 12, 2020, doi: 10.12962/j24604682.v16i1.5322.

[8] I. Pratomo, S. Wardhani, and D. Purwonugroho, “Pengaruh Teknik Ekstraksi dan Konsentrasi HCl dalam Ekstraksi Silika dari Sekam Padi untuk Sintesis Silika Xerogel,” Kim. Studentjournal, vol. 2, no. 1, pp. 358–364, 2013.

[9] H. Susilo, A. Putra, and A. Astuti, “Pengaruh Konsentrasi NaOH pada Sintesis Nanosilika dari Sinter Silika Mata Air Panas Sentral, Solok Selatan, Sumatera Barat dengan Metode Kopresipitasi,” J. Fis. Unand, vol. 5, no. 4, pp. 334–338, 2016, doi: 10.2507/jfu.5.4.334-338.2016.

[10] P. Utari, N.P.S.N., Sudiarta, I.W., dan Suarya, “SINTESIS DAN KARAKTERISASI SILIKA GEL DARI ABU VULKANIK GUNUNG AGUNG MELALUI TEKNIK SOL-GEL N. P. S. N. Utari *, I W. Sudiarta, dan P. Suarya,” J. Kim. (Journal Chem., vol. 14, no. 1, pp. 30–36, 2020.

[11] E. Dewa and R. Pasaribu, “Analisis kandungan Silikon dioksida (SiO2) pasir Pantai Koka Kabupaten Sikka dengan Metode Ekstraksi,” Pros. Semin. Nas. Fis. PPs Univ. Negeri Makassar, vol. 2, pp. 76–79, 2020, [Online]. Available: https://ojs.unm.ac.id/semnasfisika/article/view/12857.

[12] N. Fuadi, “Analisis akndungan Silika (SiO2) Pada Butuan Green Tuff Dengan Metode Gravimetrik,” Jambura Phys. J., vol. 2, no. 2, pp. 54–64, 2020.

[13] S. Sembiring and P. Karo–Karo, “Pengaruh Suhu Sintering Terhadap Karakteristik Termal Dan Mikrostruktur Silika Sekam Padi,” J. Sains MIPA., vol. 13, no. 3, pp. 233–239, 2007.

[14] S. N. Ishmah, M. D. Permana, M. L. Firdaus, and D. R. Eddy, “Extraction of Silica from Bengkulu Beach Sand using Alkali Fusion Method,” PENDIPA J. Sci. Educ., vol. 4, no. 2, pp. 1–5, 2020, doi: 10.33369/pendipa.4.2.1-5.

[15] B. Shokri, M. A. Firouzjah, and S. I. Hosseini, “FTIR analysis of silicon dioxide thin film deposited by metal organic-based PECVD,” Proc. 19th Int. Plasma Chem. Soc., no. December 2014, pp. 1–4, 2009, doi: www.ispc-conference.org.

[16] Masrur, Irmansyah, and Irzaman, “Optimasi Kelajuan Pemanasan Pada Ekstraksi,” J. Biofisika, vol. 9, no. 2, pp. 13–20, 2013.

Acknowledgments
We would like thank you to Universitas Sumatera Utara and Universitas Asahan