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# Identification and Extraction of Silica from Tuff Stones as Precursor of Synthesis Sodium Silicate

Ridha Santika[1], Syamsi Aini[*], M. Iqbal Alzain[1]

Department of Chemistry, Faculty of Mathematics and Natural Sciences, Padang State University

Jl. Prof. Hamka, Air Tawar, Padang, West Sumatera, Indonesia

*Email :syamsiaini@fmipa.unp.ac.id

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## Abstract:

Tuff stone is a pyroclastic rock with a high silica content that allows it to be used as a raw material in the synthesis of sodium silicate. This research is the identification and extraction of silica found in tuff stones. Silica on tuff stones will be used as raw material in the synthesis of sodium silicate. The tuff stone contains 76,529% silica and several other impurity metal oxides such as $Al_2O_3$, MgO, $CaCO_3$, $Fe_2O_3$, $K_2O$, $TiO_2$ and $P_2O_5$. The silica on the tuff stone is washed and dried to clean it from the soil with water, then mashed with rock grinding machines and impurities of metal oxides found in tuff stones removed with $HNO_3$ 4M at 110$^o$C and 600 rpm with magnetic stirrer. Silica extracted from tuff stones was characterized using XRF and XRD. The results of characterization using XRF showed that silica produced 93,139% purity, and the results of analysis with XRD silica found in tuff stones were crystalline and were pure silica

*Keywords* **—Tuff stones, precursors, sodium silicate**

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## I. INTRODUCTION

Silica or quartz (quartz) is a mineral that is very abundant in the earth's surface, has the chemical formula $SiO_2$ and has prominent properties, namely its high hardness (7 on the Mosh scale), and is very resistant to acids except aqua regia and HF. Silica in nature comes from igneous rock and metamorphic rock which is destroyed by weathering, undergoes transportation and then settles [9]

The Sumatra Fault Zone contains acid volcanic rocks, tuff flows, sand and floating rocky tuffs. This is because these fractures are located in orogenic regions and it is most likely that the molten acid rocks are sourced from granite rocks beneath them. The lithology of the Padang area and its surroundings consists of Pre Tertiary, Tertiary and Quaternary rocks [4].The oldest rocks that are exposed around the age are Pre-Tertiary (Jura), consisting of metamorphic rock groups that generally underlie the hills and ridges in Padang and its surroundings. This rock group consists of sedimentary meta rock (metamorphic sandstone, metamorphic silt rock) associated with the filite and the tuff / tufa clay stone (grit claystone) and the marble crystalline limestone group.

Tuff stone is one type of rock that contains high silica main elements. Tufa or tuff is a pyroclastic rock formed from material volcanic clastic and produced from a series of volcanic eruptions [1]. The maincomponent of tuff stone is $SiO_2$ and $Al_2O_3$, where the total content of $SiO_2$ and $Al_2O_3$ is in the range above 78.8%, but has not been used optimally to meet the needs of the sodium silicate industry [2]. Sodium silicate is an important compound that has many benefits in the industrial world such as; silica gel industry, soap, paper processing, detergent, zeolite, mesoporous silica and others. [3]

The need for Sodium Silicate has increased from year to year, recorded from 2010 amounting to 20,702.32 tons until 2014 amounted to 45,665.41 tons [7].On an industrial scale, commercial sodium silicate is produced in factories from calcination of sodium carbonate ($Na_2CO_3$) and $SiO_2$ at temperatures from 1400-1500$^oC$ with furnaces.Even though the raw material is cheap, the process is not economical because of its high energy consumption and maintenance costs. Recently, the production of silica from cheap raw materials has attracted much attention because it is more economical than conventional methods [8].

The need for sodium silicate is estimated for the years ahead to continue to increase. Therefore the industrial demand for sodium silicate must be accompanied by the production of sodium silicate from local materials [5].Thus, the first step of this research is the identification and extraction of silica from Tuff stone as a raw material that can be used for the synthesis of sodium silicate.

## II. METHODS

The equipment used in this study was XRD, XRF, digital scales, magnetic stirrers, ovens, 75µm sifter, 250 mL Chemical beaker, measuring cup, 5 and 20ml measuring pipettes, 50 mL volume pipettes, 250ml measuring flasks, spin bart, watch glass , pestle, furnace, filter paper, pumpkin buchner, Buchner funnel and vacuum pump.The materials used in this study were tuff, HNO3, and Aquadest samples

In this study, identification and extraction of silica from tuff stones was carried out in three stages as follows:

### 2.1 Sample selection and physical treatment

Tuff stones with high silica content were selected from Indarung Village, Lubuk Kilangan Subdistrict, Padang Municipality, ± 15 km from Padang City, West Sumatra Province at an altitude of 350 meters above sea level. The tuff stone that has been selected is then washed and cleaned from the soil attached to water and then dried. Furthermore, the tuff stone is grinded with a crusher and crushed with a grinding mill. Tuff stones that have been smooth and then sieved using a 75 µm sieve and pulled with a magnet. The next step is tuff stone stored in a dry container, placed in a desiccator, characterized by X-Ray fluorescence, X-Ray Diffraction and chemical extraction.

### 2.2 Chemical extraction

Thirty grams of mashed tuff soaked in 150 ml of 4M $HNO_3$ solution for 20 hours with a stirring speed of 600rpm at 110$^oC$, then washed with distilled water until neutral, dried with an oven at 110$^oC$ for 3 hours, then stored in a desiccator, and characterized by X-Ray fluorescence.

### 2.3 Characterization

X-Ray Fluorescence (XRF) type DWXRF minipal 4 PW403045B is used for characterization of the chemical composition of tuff stones. Meanwhile, the crystallinity of the tuff stone was characterized using X-ray diffractometer (XRD).

## III. RESULTS AND DISCUSSION

The ease of taking tuff stones, abundant availability, the safe and inexpensive purification process, high silica content, and low impurity are the advantages for exploitation of tuff stone as an industrial raw material. The existence of tuff stones in West Sumatra is found in the areas of Singkarak, Talamau, Matur, Goat Stone and in Bukit Karang Putih and in several other areas.The tuff stone on Karang Karang Hill is on the Ngalau Karang Putih hill section, on the top of Karang Putih Hill, then along the southern valley, on cliffs and landslides (Fig. 1) Based on this location, where there are tuff stones can be reached by land via the By pass, Lubuk Kilangan, Indarung to the Bukit Karang Putih mining area.

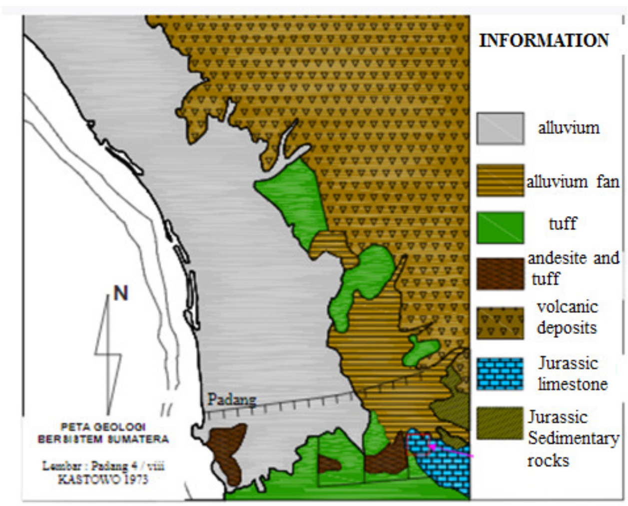



Figure 1. Geological map of Padang sheet, Scale: 1: 250,000 (Kastowo, et al, 1973)

The existence of tuffs in the white coral hills is formed from a combination of dust, rocks and mineral fragments (pyroclastic or tephra) which are thrown into the air during volcanic eruptions and then fall to the surface of the earth as a mixture of molten deposits. Melting material eruption of the mountain which is still hot reaches the surface of the earth and then freezes into chunks of tuff. Most of the rock fragments tend to be volcanic rocks that are consolidated from volcanic eruptions (Fig. 2)


Figure 2. Tuff contact zone in Bukit Karang Putih

At present, tuff stones found in West Sumatra (Fig. 3) have not been used for the sodium silicate industry. Therefore, researchers have many opportunities to identify and refine them. Identification and purification of tuff stones is the first step for all processing in the later stages of tuff stone processing such as the synthesis of sodium silicate from tuff stones. Sodium silicate can then be used as a raw material for processing paper, detergent, zeolite, and mesoporous silica.

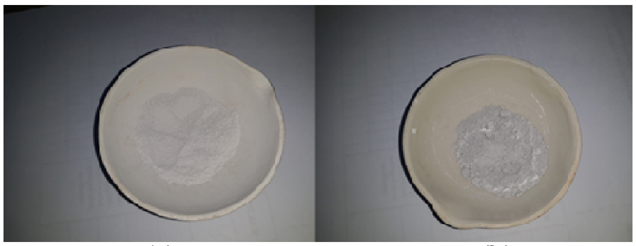
(a) (b)

Figure 3. (a) The location of the tuff stone (b) Rock tuff found on Mount Karang Putih

There are several steps in the extraction of silica in tuff stones, namely; mechanical processes, physical processes, chemical processes and heating processes. Silica in impure tuffs from magnesium, calcium oxide, alumina and iron oxide was extracted by immersing the tuff using 4M $HNO_3$ solution for 20 hours at 110°C on a magnetic stirer at 600 rpm.

Tuffstones before and after extraction with HNO3 can be seen in Figure 4. Tuffstones after being pulled magnetically and after being immersed with HNO3 are more white than tuffstones before extraction.



(a) (b)

Figure 4. (a) Tuff stone after silica extraction with 4N HNO3 and magnetized
(b) Tuff stone before being extracted and before being pulled with a magnet

The percentage of purity of oxides and $SiO_2$ from tuffs before and after extraction can be analyzed using X-ray fluorescence as shown in Table 1. Table 1 shows the three stages of silica extraction able to reduce the percentage of impurities present in tuff stones such as $CaCO_3$, MgO, $Fe_2O_3$, $Al_2O_3$, $K_2O$, TiO, and $P_2O_5$ become 7% and produce silica with a purity percentage of 93.139%.

**Table 1. Chemical composition of tuff stones before and after extraction**

| Oxside | Silicon Dioxide (%) | | |
|---|---|---|---|
| | Tuff stone before silica extraction | Tuff stone after being extracted with 3M NaOH | Tuff stone after purification with HNO3 4M |
| $SiO_2$ | 76.529 | 78.642 | 93.139 |
| MgO | 2.296 | 2.763 | 0.391 |
| $Al_2O_3$ | 14.682 | 7.614 | 3.905 |
| $CaCO_3$ | 4.581 | 7.797 | 0.703 |
| $Fe_2O_3$ | 0.777 | 1.649 | 0.232 |
| $TiO_2$ | 0.111 | 0.016 | 0.160 |
| $K_2O$ | 0.479 | 0.102 | 0.511 |
| $P_2O_5$ | 0.323 | 0.634 | 0.821 |

Impurity metal oxides found in rock tuffs such as $Al_2O_3$, $Fe_2O$, $CaCO_3$, MgO when reacted with 3M NaOH solution will produce deposits, $2Fe(OH)_3$, $Na_2CO_3$, and MgOH. While $SiO_2$ will become $Na_2SiO_3$ but in the presence of impurities, metal oxides are still quite high. If using $HNO_3$, the impurities of the metal oxides will dissolve when immersed and when filtering while silica is not, this is because silica is inert to acids except HF and Aqua regia. The remaining Al can polymerize with $SiO_2$ to become aluminacillic acid so that it can produce $AlSiO_2$. Whereas MgO and $CaCO_3$ can be precipitated in an alkaline atmosphere when sodium silicate is dissolved in water.

The type and crystallinity of the tuff stone was characterized using an X-ray diffractometer. The pattern shown by the X-ray diffractometer states that the main peak of the SiO2 is quartz at 2θ; 20,818, 26,600, 36,473, 39,424, 50,067, 59,837 and 68,052 [6]. The results of the tuff characterization using an X-ray diffractometer are shown in Figure 5.

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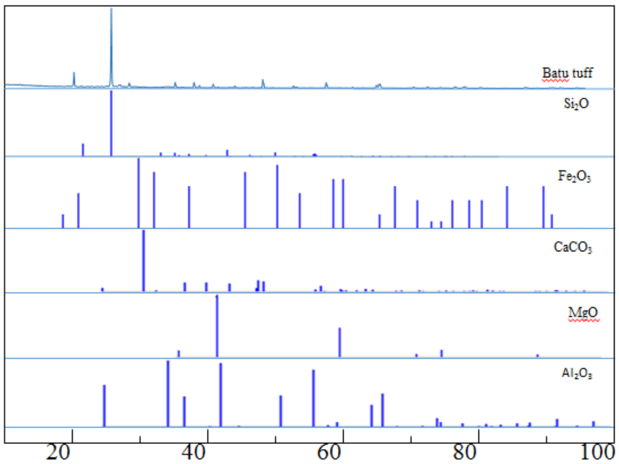


**Figure 5.** X-ray diffractogram pattern for $SiO_2$, $Fe_2O_3$,

Al2O3, CaCO3, MgO and silica on tuff stones The results of the characterization using X-ray diffractometer are in line with the characterization using X-ray fluorescence, where there are some impurity oxides such as Fe2O3, Al2O3, CaCO3, MgO and several other impurity oxides whose peaks are not visible due to their small presence. Purified tuffs contain> 93% SiO2, which is one of the ingredients used to synthesize Na2SiO3.

## IV. CONCLUSION

Based on the research that has been done, the following conclusions can be drawn;

1. The tuff stone found in Bukit Karang Putih has a silica content of 76.529% and several other metal oxides.
2. Silica on the tuff stone that is located in Bukit Karang Putih is silica which has a crystalline structure.
3. Purification of silica on tuff stones can be done in several stages, namely, tuff stone washing, tuff stone grinding into fine powder, magnetic separation and immersion with 4N HNO3 at 110oC for 20 hours.
4. Silica on tuff stones is more effective when purified using 4N HNO3 at 110oC with a purity> 93%.

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