Development Of Silica Potassium Fertilizers From Trass Rock With Calcination Process

KN Wahyusi¹, Siswanto²
¹,²Chemical Engineering study program, Engineering Faculty, UPN University, East Java, Indonesia

¹kindrinurma@gmail.com

Abstract. Rocks and sand mines have important benefits for life. With the many benefits of rocks, it is a pity if Indonesia has a lot of raw material reserves waste it. Examples of the benefits of rocks that can be converted into silica potassium fertilizer by reacting with potassium hydroxide. Examples of rocks that can be taken trass rock. The procedure for making silica potassium is by reacting 100 mesh trass rock with KOH and K₂CO₃ reagents whose composition is arranged by weight ratio, where the base of the trass rock is 100 gr. The process is carried out at a temperature of 1250 °C with a reaction time of 1 hour. The results obtained are the best silica potassium fertilizer for K₂CO₃ reagent which is 500gr: 74gr with SiO₂ content: 26.8% and K₂O content: 27.3%, with water solubility 24.02%, while for silica potassium fertilizer product from the best trass rock for KOH reagent is with a mol ratio of 400 gr: 60 gr with SiO₂ content: 23.6% and K₂O content: 22.2%, with 25.65% water solubility. The pore size of silica potassium fertilizer product of this trass rock, the range 350 – 1000 nm.

1. Introduction
Indonesia has a lot of natural resources, including sand and rock mining. Rocks and sand mining have very important benefits for human life for example that is used for building blocks of stone, cement industry and mixture of building materials. With the many benefits of these rocks, it is a pity if Indonesia has a lot of raw material reserves waste it. One more example of the benefits of rock that can be converted into silica potassium fertilizer by reacting with potassium. Stone trass is a volcanic rock that has undergone changes in chemical composition caused by weathering and the influence of underground water conditions.

Trass excavated materials found in nature generally come from pyroclastic rocks with andesitic compositions that have undergone intensive weathering up to a certain degree. Several researchers have conducted many researches on the manufacture of silica potassium fertilizers in the scale of the plant as well as in the laboratory scale. Segawa, H., et al. [1] have conducted a factory-scale research entitled Process For Producing Potassium Silicate Fertilizer And Apparatus For Practicing Said Process, they made silica potassium fertilizer from fly ash mixed with potassium source and calcined at a temperature of about 600 -1100 °C. Amalinda, L., et al [2] have conducted a plant-scale research entitled The Making of Potassium Silica Fertilizers Dissolved In Citric Acid From Coal Fly Ash, they make silica potassium fertilizer from a mixture of potassium carbonate, potassium hydroxide, fly ash, coal powder, Magnesium hydroxide and alcoholic waste which are then calcined. Muljani, S., et al [3] have conducted research on the manufacture of silica potassium fertilizer from geothermal sludge and
pyrophyllite which have high silica content, silica potassium yield obtained after reacting with \( \text{K}_2\text{CO}_3 \) that is 60-70% with temperature 600-1000 °C. Year (2016) Muljani, S., et al conducted research on Silica Potassium Fertilizer Production from Waste PLTB with Fusion Method, with silica content in raw materials 80% of the best results obtained, 63.6% \( \text{SiO}_2 \) and 30.0% \( \text{K}_2\text{O} \) for \( \text{K}_2\text{CO}_3 \) reagents, Whereas for reagent KOH got \( \text{SiO}_2 \) of 62.0% and \( \text{K}_2\text{O} \) of 31.4%. Trass stone has a silica content of about 30% - 50%.

The content is relatively small when compared with other silica content, such as silica content in geothermal sludge and rice husk but silica fertilizer is formulated to contain 20% - 26% of differentiated \( \text{SiO}_2 \) Its use between optimal wetland and suboptimal land, so the stone trass can still be an alternative to be applied to silica fertilizer. Having relatively small silica content of trass stone can still be an alternative to be used as raw material for making silicate fertilizers applied to marginal lands, swamp land (peatland, acid, lebak), rainfed land, dry land, emememic areas of disease, poisoning Iron and badly drained fields that require relatively low silica content. Silica potassium fertilizer is not common in Indonesia, but in some countries this fertilizer has been widely applied to the agricultural sector. Silica potassium fertilizer is an element that contains elements of Silica (Si) and potassium (K), both of these elements are needed by plants. The purpose of this research is to know the effect of weight ratio in making silica potassium fertilizer from rock trass and to know the composition of silica potassium fertilizer product made using stone trass material with reagent KOH and \( \text{K}_2\text{CO}_3 \).

2. Materials and Method

Raw Materials Used in this research is Batu Trass taken from Village Terjan Rembang District Central Java content Si 32.3 %. Ratio of trass with KOH, the weight of tras rock varies from 100gr to 500 gram where the weight of KOH remains 60 grams. Ratio of trass with \( \text{K}_2\text{CO}_3 \), the weight of tras rock varies from 100gr to 500 gram whereas the weight of Potassium carbonate stays 74 grams. The tras rock is washed and mashed up to 100 mesh size and then added KOH / \( \text{K}_2\text{CO}_3 \) according to the variable stirred until blended while the water is dropped and then put into calcination in the furnace at 1259°C for 1 h then the product from furnace cooled and mashed.

3. Results and Discussion

In this study, the comparative study of potassium hydroxide (KOH) and potassium carbonate (\( \text{K}_2\text{CO}_3 \)) with response variables, namely the composition of silica potassium product (\( \text{K}_2\text{O} \cdot \text{SiO}_3 \)), solubility of potassium silica in water and particle pore size was evaluated.

Effect of Raw Material Ratio (Trass / KOH) Against Product Composition

| Weight Ratio Trass / KOH | Product Potassium Silica Fertilizer |
|--------------------------|-------------------------------------|
|                          | \( \text{SiO}_2 \) (\%) | \( \text{K}_2\text{O} \) (\%) |
| 100 : 60                  | 12.8                           | 51.7                        |
| 200 : 60                  | 16.5                           | 31.2                        |
| 300 : 60                  | 21.1                           | 26.4                        |
| 400 : 60                  | 23.6                           | 22.2                        |
| 500 : 60                  | 25.2                           | 11.4                        |

Based on the data from table 1 it is found that the greater the ratio of silica to KOH then the silica content in the product will be greater and vice versa, the potassium content will be smaller, at a ratio of 100gr: 60gr \( \text{SiO}_2 \) : 12.8% and \( \text{K}_2\text{O} \) : 51.7% 200gr: 60gr obtained \( \text{SiO}_2 \) content: 16.5% and \( \text{K}_2\text{O} \) : 31.2%, and for further comparison the \( \text{SiO}_2 \) content continues to increase while the \( \text{K}_2\text{O} \) content decreases to a ratio of 500gr : 60gr with \( \text{SiO}_2 \) content: 25.2% and \( \text{K}_2\text{O} \) content : 11.4%. Potassium composition decreases
as the amount of processed silica gets larger. Effect of Raw Material Ratio (Trass / K$_2$CO$_3$) on Product Composition.

**Table 2. Effect of Raw Material Ratio (Trass / K$_2$CO$_3$)**

| Weight Ratio SiO$_2$ / K$_2$CO$_3$ | Product Potassium Silica Fertilizer | SiO$_2$ (%) | K$_2$O (%) |
|----------------------------------|-------------------------------------|-------------|------------|
| 100 : 74                         |                                     | 16.5        | 39.7       |
| 200 : 74                         |                                     | 19.5        | 32.4       |
| 300 : 74                         |                                     | 22.2        | 27.8       |
| 400 : 74                         |                                     | 24.3        | 27.6       |
| 500 : 74                         |                                     | 26.8        | 27.3       |

Based on data from table 2 it is found that the ratio of silica raw material to potassium has an effect on the composition of silica potassium product. The process of calcining pyrophylite rocks with potassium carbonate at a temperature of 600-1000 °C [3], for tras rocks at 1250 °C of silica and K$_2$CO$_3$ has melted to form a reaction of silica potassium, where the greater the ratio of silica to K$_2$CO$_3$, the content Silica in the product will be larger and vice versa, the potassium content will be smaller, at a ratio of 100gr : 74gr obtained SiO$_2$ : 16.5% and K$_2$O : 39.7%, then in the ratio of 200gr : 74gr obtained SiO$_2$ content : 19.5% and K$_2$O : 32.4%, and for further comparison the SiO$_2$ content continues to increase while the K$_2$O content decreases. Potassium composition decreases as the amount of processed silica gets larger. From the table can also be seen that the quality of silica potassium fertilizer produced can be tailored to the needs. How to adjust the product to fit the desired needs, namely by adjusting the ratio of the amount of silica to reactions.

**Effect of Ratio on Solubility of Potassium Silica Fertilizer in Water**

![Figure 1. Effect of Ratio on Solubility of Potassium Silica Fertilizer in Water](image)

Based on figures it is found that the greater the ratio of silica to the actors, the greater the number of products produced. This is because the greater the silica is added, silica potassium fertilizer contains elements of Silica and Potassium needed by plants (Sumada, 2013).

**Pore Size of Potassium Silica Fertilizer**
Based on the data from Fig. 2 and 3, there was obtained a non-uniform particle size, partly microporous and partly nanopore-sized. But from the picture above the pore size that dominates is the size of nanopor. The effect of the pore size of the fertilizer particles, ie the smaller the pore size of a fertilizer, the fertilizer is able to bind the soil particles to a better aggregate, to improve the soil pore size distribution so that the water holding capacity of the soil is better and the air movement Aeration in the soil also becomes better, and also acts as a soil enhancer to improve long-term physical, chemical, and biological fertility.

4. Conclusion

Based on the results of research that has been done concluded that:

The addition of the amount of processed silica has an effect on the product of silica potassium fertilizer while the product that has complied with the formulation required by rice field for KOH reagent is 4:1 mole ratio with SiO₂ content: 23.6% and K₂O content: 22.2%, with water solubility equal to 25.65%. The result of silica potassium fertilizer product that has complied with the formulation required by rice field for K₂CO₃ reagent is 5:1 mole ratio with SiO₂ content: 26.8% and K₂O content: 27.3%, with 24.02% water solubility. The best quality of silica potassium from trass stone was obtained from K₂CO₃ reagent with SiO₂ content: 26.8% and K₂O content: 27.3%, but economically KOH reagent has cheaper price compared to K₂CO₃ with SiO₂ content: 23.6% and K₂O content: 22.2%, with a water solubility of 25.65%.

5. Acknowledgment

We would like to thank the Head of Chemical Engineering for the facility. We also thank to the team of Material Research group, Chemical Engineering Department, UPN Veteran Jawa Timur.

6. References

[1] Segawa, H., Akizuki, K. 1982. "Process For Producing Potassium Silicate Fertilizer and Apparatus For Practicing Said Process". United States Patent.
[2] Amalinda, L., Elisabeth, M., Megantari, U. 2012. "Making Silica Potassium Fertilizers Dissolved In Citric Acid From Flying Abu Coal".
[3] Muljani, S., Wahyudi, B. 2016 "Production of Silica Potassium Fertilizer From Waste PLTB With Fusion Method". Surabaya; UPN "Veteran" East Java.
[4] Jiangtao C, Jun W, Fei Z, De Y, Guangan Z, Renfu Z, Pengxun Y 2000 Structure and photoluminescence property of Eu-doped SnO2 nanocrystalline powders fabricated by sol–gel calcination process.

[5] Kartohardjono, A. 2007 Silicones: Important Haran on Rice Production System". Food Crop Science and Technology 2 2.

[6] Christensen NH, Cooper A, Rawal BS 2010 Kinetics of Dendritic Precipitation of Cristobalite from a Potassium Silicate Melt”, Inter J of the Phys Sci 5 9 1419-1423.

[7] Shangfeng Du, Yajun Tian, Haidi Liu, Jian Liu, and Yunfa Chenw 2006 Calcination Effects on the Properties of Gallium-Doped Zinc Oxide Powders” Multi-Phase Reaction Laboratory, Institute of Process Engineering, Chinese Academy of Sciences, Beijing 100080, China, J. Am. Ceram. Soc., 89 8 2440–2443.

[8] Xiaobo Y, Miguel A. C,†Yongjae L, Haiming L, David H. Olson 2004 Synthesis and Crystal Structure of As-Synthesized and Calcined Pure Silica Zeolite ITQ-12 J Am. Chem. Soc., 126 33 10403–10409.

[9] Yi-Cheng L, Long W, Shyh-Shan L 2008 Pb(Mg1/3Nb2/3)O3 Ceramics Produced by Modified Two-Stage Calcination Process Japanese J. of Appl Phys, 33 2 9B.

[10] Yuan-He S, Lin-Bing S, Tian-Tian L, Xiao-Qin L Modulating the Host Nature by Coating Alumina: A Strategy to Promote Potassium Nitrate Decomposition and Superbasicity Generation on Mesoporous Silica SBA-15” State Key Laboratory of Materials-Oriented Chemical Engineering, College of Chemistry and Chemical Engineering, Nanjing University of Technology, Nanjing 210009, China, J. Phys. Chem. C, 114 44 18988–18995.