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# Stationary Phase Performance Based on Calcium Oxide/Silica Gel on Thin- Layer Chromatography for Xanthone Derivative Compounds

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**Abstract.** Composite CaO/SiO<sub>2</sub> as a stationary phase material in the chromatography system was carried out as an innovation in overcoming the weaknesses of SiO<sub>2</sub>. Testing of CaO/SiO<sub>2</sub> material as a stationary phase was carried out on thin-layer chromatography (TLC). CaO/SiO<sub>2</sub> material was fabricated using the casting method with methanol: water (3:1). CaO/SiO<sub>2</sub> material was tested for its performance in elucidating  $\alpha$ -mangosteen samples. Characterization of CaO/SiO<sub>2</sub> material was carried out using FT-IR and XRD instruments. The FT-IR spectra of CaO/SiO<sub>2</sub> composite shows the existence of each component of the functional group of CaO and SiO<sub>2</sub>. This is indicated by the presence of a peak of 1102 cm<sup>-1</sup> which is the vibration of the siloxane group (Si-O-Si), 1445 cm<sup>-1</sup>, and 875 cm<sup>-1</sup> which is an attribute of ionic vibration of the CaO material, where each of these peaks is visible and do not affect each other in all variations of the composition. The X-ray diffractogram shows that the CaO/SiO<sub>2</sub> material has a semi-crystalline form which is characterized by a crystalline percentage value of 38.90% and has an average crystal size of 234.24. The  $\alpha$ -mangosteen compounds have varied functional groups. The results of the performance test of CaO/SiO<sub>2</sub> as a stationary phase showed that the minimum and maximum composition variation to be capable of elucidating  $\alpha$ -mangosteen compounds were 10% and 60% CaO variation. The process of  $\alpha$ -mangosteen elucidation with the stationary phase of CaO/SiO<sub>2</sub> composite also showed the important role of the eluent polarity.

## INTRODUCTION

Chromatography is a separation technique based on the polarity of a material [1]. In general, chromatography has a stationary phase and a mobile phase. The stationary phase in chromatographic techniques generally uses silica gel (SiO<sub>2</sub>) which is applied in the separation of organic and inorganic compounds [2,3]. Silica gel is an amorphous form of SiO<sub>2</sub> with a highly porous structure, while the surface of hydrated silica is covered with hydroxyl groups attached to Si atoms, and these hydroxyl groups can exist in a free or bound state [4]. In general, SiO<sub>2</sub> material has several forms of crystal structure including tetragonal, hexagonal, and monoclinic [5]. Separation using SiO<sub>2</sub> material as the stationary phase still has shortcomings and limitations in separating compounds containing various functional groups [6]. This limitation of SiO<sub>2</sub> is caused by the characteristics of the SiO<sub>2</sub> material which has an amorphous phase form with an irregular and non-uniform arrangement of atoms to provide the potential for physical and chemical interactions [7]. Another characteristic shows that the surface of SiO<sub>2</sub> is still dominated by siloxane and silanol groups which are polar and have large pores.

Several studies that have been carried out to improve the shortcomings of SiO<sub>2</sub> as a stationary phase are mostly carried out by combining various types of materials. The research conducted by Ehrling, *et al.* [8] who have combined Metal-Organic Frameworks (MOF) with SiO<sub>2</sub> showed high affinity for the separation of ethylbenzene and styrene with n-hexane/ethyl acetate (1:1). The MOF/SiO<sub>2</sub> composite showed selectivity which was dominated by the polarity

of the mobile phase. The results of other studies carried out to overcome the shortcomings of SiO<sub>2</sub> material as a stationary phase were also carried out by combining ZrO<sub>2</sub> with SiO<sub>2</sub> which can separate adenosine 5-monophosphate compounds [9]. Various kinds of combinations or modifications that have been carried out still have other obstacles in the form of compound samples that are still too specific only for certain groups of compounds and the modification process requires relatively expensive costs.

In this research, the fabrication of CaO/SiO<sub>2</sub> material as the stationary phase in the chromatographic system has been carried out. The choice of CaO as a combination material is because CaO has porous characteristics and has a large surface area. According to Lim, *et al.* (2009) [10], commercial CaO has a particle size of 0.031 m and a surface area of 21 m<sup>2</sup>/g. Another characteristic shows that the surface of CaO contains oxygen anions so that it has the ability to carry out hydrogen bonds. CaO material has the characteristics of a crystalline phase, so it has good potential to be combined with SiO<sub>2</sub>. CaO material also has the ability as an adsorbent to separate gas from the distillation of algal biomass which is then broken down into residues in the form of H<sub>2</sub>, CO<sub>2</sub>, CO and CH<sub>4</sub> [11]. Another ability of CaO as an adsorbent is also shown in its ability to adsorb CO<sub>2</sub>. CaO-based adsorbents showed higher CO<sub>2</sub> adsorption capacity and better cycle performance compared to slag carbide [12]. The type of chromatography used in applying CaO/SiO<sub>2</sub> material as the stationary phase is Thin Layer Chromatography (TLC). This is because TLC is one of the simplest chromatographic techniques.

## MATERIALS AND METHOD

### Materials

The equipments needed in this study are a set of commonly used glassware, the TLC stationary phase, buffer material to be used is 8 cm × 2 cm × 0.2 cm prepared glass, a hotplate heater, and an oven. The materials used are CaO (Merck), SiO<sub>2</sub> 7749 (Merck), the solvent used is an organic solvent, namely methanol: H<sub>2</sub>O. The sample used to test the CaO/SiO<sub>2</sub> material as a stationary phase in the chromatographic system is the α-mangosteen compound, which has been isolated from the mangosteen rind.

### Fabrication of Material

CaO and SiO<sub>2</sub> powders were weighed according to the composition variations as shown in Table 1. The mixture of CaO and SiO<sub>2</sub> was carried out according to the percentage of their respective compositions and dissolved with methanol: water (3:1) until homogeneous and in the form of a slurry. The buffer material in the form of glass preparations was first immersed in methanol and sonicated for 2 minutes to clean the surface of the glass preparations.

TABLE 1. Variations in the Composition of CaO/SiO<sub>2</sub>

Material	Composition variation (%)										
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
CaO	10	20	30	40	50	60	70	80	90	100	0
SiO <sub>2</sub>	90	80	40	60	50	40	30	20	10	0	100

CaO/SiO<sub>2</sub> slurries with various compositions were printed on the surface of the glass preparations by the casting method. The printed plate was left for 10 minutes and then heated to a temperature of 50 °C. The use of a temperature of 50 °C is done to avoid the use of high temperatures that can cause changes in the shape of the CaO/SiO<sub>2</sub> materials [13].

### TLC Performance Test Based on CaO/SiO<sub>2</sub>

The performance test of TLC I-XI (Table 1) which has been fabricated with variations in the composition of CaO/SiO<sub>2</sub> was carried out with xanthone derivatives isolated from mangosteen rind. The types of eluents used were Ethyl acetate: n-hexane (7:3), Methanol: chloroform (8:2), and Chloroform: Toluene (7:3). Good TLC performance

is indicated by the formation of well-separated spots. To clarify the observations of the formed spots, TLC will be assisted with Iodine Steam and UV lamps.

## Characterization

The characterization of the CaO/SiO<sub>2</sub> material was carried out using FTIR and XRD which aims to confirm the functional groups contained in the combined material and the crystal structure of the CaO/SiO<sub>2</sub> composite by data from the Joint Committee on Powder Diffraction Standards (JCPDS). The value of the XRD characterization results can also be used to determine the size of the crystal with a certain phase.

## RESULTS AND DISCUSSION

### Characterization of Material

The use of CaO as a stationary phase in the technique of separating organic compounds is innovative. In this study, the use of CaO as a stationary phase is in the form of TLC. Mixing CaO and SiO<sub>2</sub> were carried out with methanol: water in a ratio (3:1) to form a paste which is then printed on the surface of the glass with casting technique. The existence of each component after being deposited on a glass slide is characterized by FT-IR (Fig. 1). The existence of silica gel is visible with the presence of an absorption peak at the 3470 cm<sup>-1</sup> wavenumber which shows the vibration of the -O-H bond as a silanol group, and at 1102 cm<sup>-1</sup> wave number which is the vibration of -Si-O-Si- bond of the siloxane group [14] that appears on all samples. This shows that the existence of SiO<sub>2</sub> is independent in the mixture.

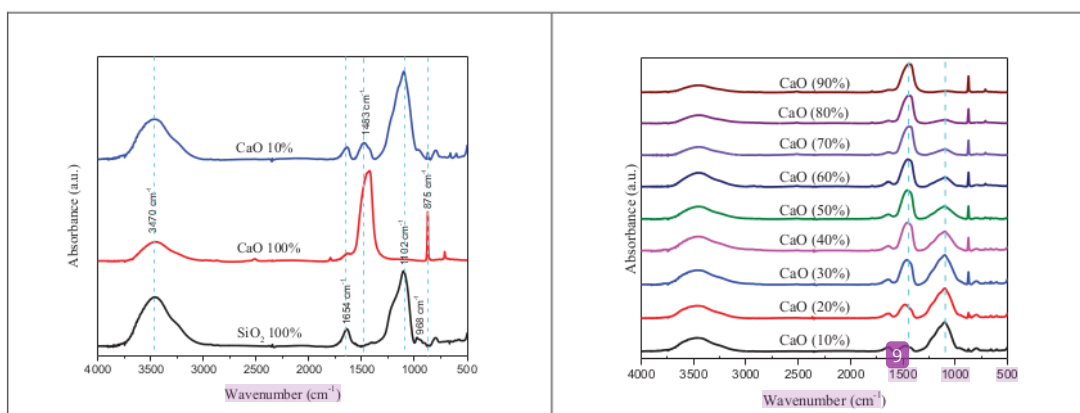


FIGURE 1. FT-IR spectrum of CaO, SiO<sub>2</sub> (left) and various CaO/SiO<sub>2</sub> compositions (right)

Figure 1. shows new absorption peaks where the absorbance continued to increase with increasing levels of CaO against SiO<sub>2</sub>. The peak at 3480 cm<sup>-1</sup> wavenumber is the peak due to the absorption of O-H bonds vibration that appear in all samples. This indicates the absorption of water vapor in the surface of CaO and SiO<sub>2</sub> considering that both SiO<sub>2</sub> and CaO are oxides that is very easy to absorb vapor water, so it can be said that there is a Ca(OH)<sub>2</sub> phase [15,16]. The peak at wavenumbers of 1445 cm<sup>-1</sup> and 875 cm<sup>-1</sup> are attributes of the sample that contains CaO. The absorption peak of 1445 cm<sup>-1</sup> wavenumber was identified as a vibration of the C-O bond in the carbonate ion while at the 875 cm<sup>-1</sup> wavenumber was identified as a bond vibration of Ca-O that tends to be rigid [12,17]. The FT-IR shows that CaO is present in Ca(OH)<sub>2</sub> species that appear as a consequence of absorption of water vapor and CaCO<sub>3</sub> consequences of absorption of free CO<sub>2</sub> gas in the air. Nevertheless, it does not interfere with the existence of SiO<sub>2</sub>. Therefore, this mixture can be bonded to form a composite, compared to new components, considering the temperature processing is still below 100 °C.

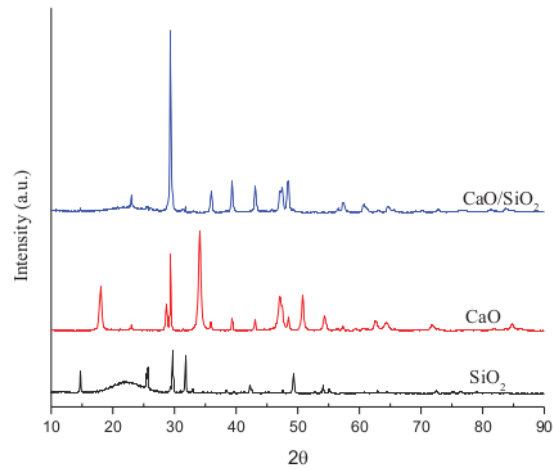
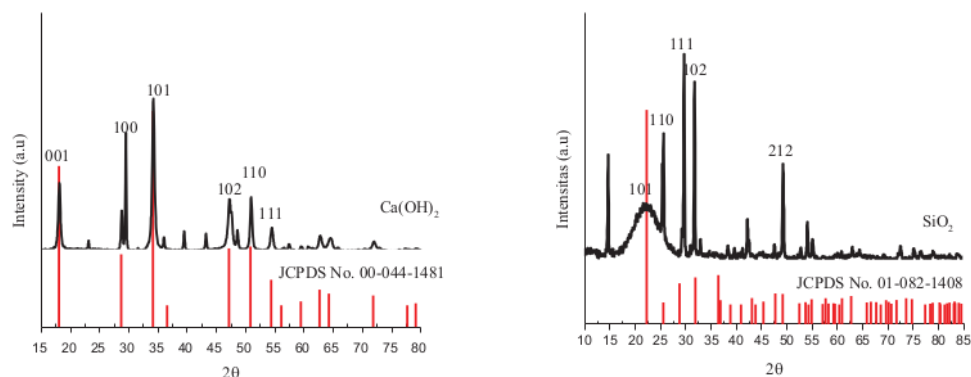


FIGURE 2. Material diffractogram of 100% CaO, 10% CaO and 100% SiO<sub>2</sub>

The diffractogram plotting of three samples is shown in Figure 2. The presence of a widening peak for the 100% SiO<sub>2</sub> sample at an angle range of 18°-25°, indicates the presence of silica in amorphous form. However, sharp peaks were seen at some 2θ angles indicating the presence of a crystalline phase of SiO<sub>2</sub>. The percentage of crystallinity of SiO<sub>2</sub> can be calculated by integrating the crystalline peaks against the amorphous peaks using the value of FWHM. Calculation of the percentage of crystallinity for SiO<sub>2</sub> showed results that reached 27.39%. The results of this calculation indicate that the SiO<sub>2</sub> material used in this study may be in a semi-crystalline form. The crystalline form of CaO material identified in XRD data with angles of 32.24°, 37.39°, 42.92°, 53.89°, 54.12°, 64.20°, and 67.43°. The results of the calculation of the percentage of crystallinity of the CaO material showed a result of 66.11%. These results indicate that the CaO material is in the crystalline phase. The determination refers to the main peaks of the diffractogram pattern through the Debye Scherrer equation approach which is formulated as in equation 1.

$$D = \frac{K\lambda}{\beta \cos\theta} \quad (1)$$

D is the average crystal size, K is the form factor of the crystal (0.9-1), λ is the wavelength of X-rays of 1.54056, β is the value of Full Width at Half Maximum (FWHM) obtained from the results of XRD data analysis and θ is the diffraction angle. The results of the calculation of the crystal size that have been carried out using the Scherrer equation that is shown in Table 2.



**FIGURE 3.** Comparison of X-Ray diffractogram on  $\text{Ca(OH)}_2$  and  $\text{SiO}_2$  with samples

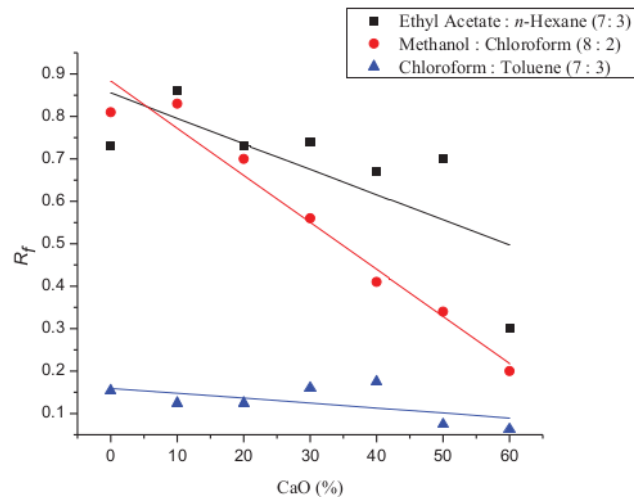
The diffractogram analysis of each sample was carried out by comparing data from the Joint Committee on Powder Diffraction Standards (JCPDS). Based on Figure 3 the results of the diffraction pattern of  $\text{CaO}$  material matched with the diffraction pattern of JCPDS as a comparison. It can be seen that the  $\text{Ca(OH)}_2$  phase dominates the crystal system for the  $\text{CaO}$  sample. This is concluded based on the level of conformity of the diffractogram peak with the JCPDS No. standard. 00-044-1481, based on this standard  $\text{Ca(OH)}_2$  adopts a trigonal crystal system with hkl planes 001, 100, 101, 102, 110, and 111. The diffraction pattern of the  $\text{SiO}_2$  material matched with JCPDS No. data. 01-081-0069. It can be seen that the tested  $\text{SiO}_2$  sample is dominated by a tetragonal crystal system, where Si has a coordination number of 8 for O, so that  $\text{SiO}_2$  has the characteristics of a porous material. However, it can also be seen that there are peaks that do not comply with the JCPDS standard No.01-081-0069 which is an *Ortho* rhombic crystal system with a peak at an angle of  $14^\circ$ . This is because the  $\text{SiO}_2$  sample is polycrystalline which can form other phases.

**TABLE 2.** Crystal percentage and crystal system

Sample	Percent of crystallinity (%)	Average crystal size (nm)	Crystalline system
CaO	66.11	254.90	Trigonal
$\text{SiO}_2$	27.39	317.92	Tetragonal
CaO/ $\text{SiO}_2$	38.90	234.24	-

### Performance Test of $\text{CaO/SiO}_2$ Material as Stationary Phase in Thin Layer Chromatography

Performance tests of TLC on a variation of composition and eluent are carried out against xanthone-derived compounds isolated from the mangosteen fruit peel. Based on previous research, which carried out the identification of xanthone-derived compounds from the peel of the mangosteen fruit by using TLC commercial silica-based with a mobile phase that is dominated by less polar solvents i.e., chloroform: ethyl acetate (9:1), the  $R_f$  value was 0.48 [18]. The use of the same type of eluent of this study for TLC with various compositions of  $\text{CaO}$  did not provide a  $R_f$  value because the spot of the sample did not move. This matter can be explained by the effect of adding  $\text{CaO}$  on silica, where  $\text{CaO}$  which is the basic oxide with ionic bonds will certainly give polarity variations on the TLC surface. Therefore, this study combined several variations of eluent at each compositional variation of  $\text{CaO}$ , where more polar solvents are always made with larger comparisons.

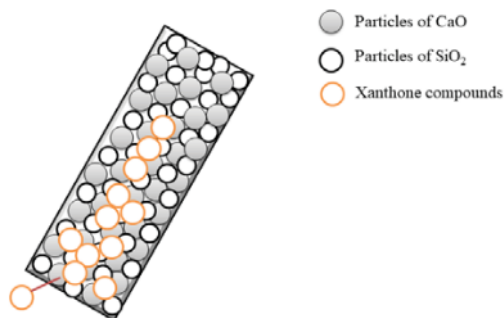


**FIGURE 4.**  $R_f$  values of  $\alpha$ -mangosteen compounds on various eluent compositions and CaO compositions on  $\text{SiO}_2$

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Figure 4. shows that the plotting of each eluent  $R_f$  value showed a linear decrease as the CaO content increased. Based on these results, the polarity gradient of the eluent component is correlated with the range of  $R_f$  values, where the combination with large porosity differences gives a wider range of  $R_f$  values, and vice versa. Solvent types can be sorted by polarity (polarity index) i.e., Methanol (5.1) > ethyl acetate (4.4) > Chloroform (4.1) > Toluene (2.4) > n-Hexane (0.1) [19]. Ideally, the  $R_f$  value has a range of 0.8-0.2 [20]. The combination of methanol: chloroform has a very polar nature compared to other eluents so that it will make the  $\alpha$ -mangosteen compound more retained. Besides, other factors that cause the decreased ability to separate the  $\alpha$ -mangosteen compound is the result of the molecular weight of the eluent methanol: chloroform is small.

The difference in polarity between the eluent and the CaO/ $\text{SiO}_2$  material in elucidating  $\alpha$ -mangosteen compound resulted in variations of  $R_f$  values. This shows that the polarity of each eluent correlates with the obtained  $R_f$  value. This difference in polarity indicates that the greater the CaO composition, the more retained the  $\alpha$ -mangosteen compound could be separated. The mechanism of  $\alpha$ -mangosteen elucidation was done by increasing the polarity of the stationary phase.  $\text{SiO}_2$  material is a porous compound so it can be inserted with more polar CaO material. Based on the results of the separation with various variations of CaO/ $\text{SiO}_2$  material composition, the minimum composition to separate  $\alpha$ -mangosteen compounds is 10% of CaO, while the maximum composition of stationary phase material is 60% CaO.



**FIGURE 5.** Elucidation mechanism of  $\alpha$ -mangosteen on CaO/ $\text{SiO}_2$  material as stationary phase



This indicates that the composition variation of 10% - 60% has the ability to elucidate  $\alpha$ -mangosteen compounds well which is characterized by the formation of one spot. Plotting the Rf data shows a suitable separation pattern with the eluent used. In this case, the separation of  $\alpha$ -mangosteen compounds using methanol: chloroform can be suggested using a combination of materials with a CaO ratio of 30%. It is suspected that physical interactions between functional groups correspond to the polarity of the stationary phase. More polar functional groups will interact strongly with CaO and vice versa. The depiction of the interaction of  $\alpha$ -mangosteen compounds to be separated using Ca/SiO<sub>2</sub> stationary phase material can be seen in Figure 5.

## CONCLUSION

The existence of each component of CaO and SiO<sub>2</sub> is still clearly visible, which indicates that the two components only mix with the role of filler and matrix. The characteristics of the CaO/SiO<sub>2</sub> material have a semi-crystalline by a crystalline percentage value of 38.90% and has an average grain size of 34.24 nm. The test results for CaO/SiO<sub>2</sub> as a stationary phase in a chromatographic system shows that CaO/SiO<sub>2</sub> can be used as a stationary phase. The minimum composition variation in separating  $\alpha$ -mangosteen compounds was 10% of CaO and the maximum composition variation was 60% of CaO. CaO/SiO<sub>2</sub> material as a stationary phase can elucidate  $\alpha$ -mangosteen compound with the formation of one spot. Variations in the composition of CaO/SiO<sub>2</sub> materials that are similar to the standard in eluting  $\alpha$ -mangosteen compound are shown at 10% and 20% CaO compositions.

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## REFERENCES

1. V. Matei, I. Comanescu, and A. Borcea, "Stationary Phases", in *Advanced Gas Chromatography - Progress in Agricultural, Biomedical and Industrial Applications*, edited by Mustafa Ali Mohd, (IntechOpen, Romania, 2012), p. 27-50.
2. U. A. Brinkman, G.D. Vries, and R. Cuperus, *Journal of Chromatography* **198**, 4, p.421-428 (1980).
3. X-L. Yang, B. Zhao, F. Feng et al, *Chinese Journal of Analytical Chemistry* **47**, 6, p.832-837 (2019).
4. S. Faramawy, A. Y. El-Naggar, A. M. El-Fadly, S. M. El-Sabagh, and A. A. Ibrahim, *Arabian Journal of Chemistry* **9**, p.765-775, (2011).
5. K. Persson, Materials Data on CaO (SG: 194) by Materials Project. *Material Project*. [Online] July 2014. [Cited: July 20, 2021.] www.materialsproject.org.
6. H. Zhang, Q. Xaio, T. Cai, J. Chen, Z. Li, and H. Qiu, *Analytical and Bioanalytical Chemistry*, **409**, 9, pp. 2401-2410 (2017).
7. L. Chen, J. Gao, Q. Wu, H. Li, S. Dong, X. Shi, and X. Zhao, *European Polymer Journal* **116**, p. 9-19 (2019).
8. S. Ehrling, C. Kutzscher, P. Freund, P. Mueller, I. Senkovska, and S. Kaskel, *Microporous and Mesoporous Materials* **263**, p.268-274 (2018).
9. Qing Wang, Z-Y. Luo, M. Ye, Y-Z. Wang, L. Xu, Z-G. Shi, and L. Xu, *Journal of Chromatography A* **1382**, p.58-69 (2015).
10. B. P. Lim, G. P Maniam, and S. A Hamid, *European Journal of Scientific Research* **33**, p. 347-357 (2009).
11. X. Yan, Y. Li, C. Sun, and Z. Wang, *Fuel* **287**, 119554, (2020).
12. K. Liu, B. Zhao, Y. Wu, F. Li, Q. Li, and J. Zhang, *Fuel* **269**, 117481 (2020).
13. D. M. Roy and R. Roy, *The American Mineralogist* **49**, 952-962 (1964).
14. S. R. Darmakkolla, H. Tran, A. Gupta, and S. B. Rananavare, *RSC Adv.* **6**, 95, (2016).
15. A. Kawashima, K. Mitsubara, and K. Honda, *Bioresource Technology* **100**, 696-700 (2008).
16. P. Raizada, P. Shandilya, P. Singh, and P. Thakur, *Journal of Taibah Uni. for Sci.* **11**, 5, p. 689-699, (2017).
17. W. Guan, F. Ji, Y. Cheng, Z. Fang, D. Fang, P. Yan, and Q. Chen, *Journal of Nanomaterials* **2013**, 1, (2013).

18. M. Galvan-Ruiz, J. Hernandez, L. Banos, and J. Noriega-Montes, *Journal of Material in Civil Engineering* **21**, 11, (2009).
19. K. Ramluckan, K. G. Moodlay, and F. Bux, *Fuel* **116**, p.103-108 (2014).
20. I. G. Gandjar and A. Rohman. *Analisis Obat Secara Spektrofotometri dan Kromatografi*, (Pustaka Pelajar, Yogyakarta, 2012).

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