

Preparation and characterization of KF/CaO- MgO catalyst for monoglycerides synthesis

by Indro Sumantri

Submission date: 26-Jan-2022 03:59PM (UTC+0700)

Submission ID: 1748460693

File name: 2019-Paper-Didi_DA-Malaysia-Thompson-2019.pdf (697.8K)

Word count: 3518

Character count: 18197

Preparation and characterization of KF/CaO-MgO catalyst for monoglycerides synthesis

Didi Dwi Anggoro*, Luqman Buchori, Indro Sumantri, Herawati Oktavianti

Department of Chemical Engineering, Faculty of Engineering, University of Diponegoro, Jl. Prof. Sudharto, Tembalang, Semarang, 50239, Indonesia

* Corresponding author: anggorophd@gmail.com

23

Article history

Received 24 July 2018
 Revised 2 August 2018
 Accepted 29 November 2018
 Published Online 15 October 2019

Abstract

A heterogeneous KF/CaO-MgO catalyst was prepared by impregnation method and was characterized by X-ray diffraction, BET and Tanabe method. The effects of weight KF addition, temperature and time of calcination on catalyst preparation were investigated. The influence of basicity value of catalyst was investigated. KF/CaO-MgO catalyst could perform the active sites to produced a high MG yield of 47.96% for 2%w KF addition, at 550 °C of calcination temperature and 2 hours of calcination time. It has a high specific surface area (110,924 m²/g) that favorable for contact between catalyst and substrates, which effectively improved efficiency of glycerolysis. The high activity of the catalyst was described to the formation of KCaF₃ and MgKF₃ crystals.

Keywords: KF/CaO-MgO catalyst, basicity, impregnation method, glycerolysis, monoglycerides

© 2019 Penerbit UTM Press. All rights reserved

INTRODUCTION

To date, monoglycerides (MG) needed by the industry is increasing. MG is widely used as emulsifier, wetting agent, lubricant and so on in the food industries, cosmetics, pharmaceuticals [1, 2], oil well drilling [3], textile [4], packaging [5], plastic processing [6], and material construction [7].

Indonesia is one of the largest producer countries of palm oil in the world. Indonesia's crude palm oil (CPO) production had shown a significant increase over the last 5 years. In 2012, Indonesia had produced palm oil as much as 26 million tons and reached 33.2 million tons by 2016 [8]. More than half of palm oil production is used to meet domestic demand especially the cooking oil industry and the rest is exported. Utilization of palm oil is less effective due to the lack of development in downstream palm oil industries. Palm oil contains 41% saturated fat, 81% palm kernel oil, and 86% coconut oil [10].

Table 1 Composition of fatty acid on palm oil [9].

No	Component	Mass %
1	Myristic Acid	1,1 – 2,5
2	Palmitic Acid	40-46
3	Stearic Acid	3,6-4,7
4	Oleic Acid	39-45
5	Linoleic Acid	7-11

There are several methods of making monoglycerides, among others, through the direct esterification of glycerol and esterification of indirect glycerol by transesterification of glycerol-triglyceride or glycerol-fatty acid of methyl ester (FAME), glycerolysis, enzymatic reactions and chemical deactivation. Glycerolysis reactions are simpler and more economical because they do not require the process of hydrolyzing fat into fatty acids, the separation of fatty acids,

purification and selective esterification steps as in enzymatic methods [11].

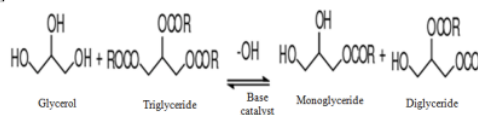


Fig. 1 Glycerolysis reaction [11].

Glycerolysis is an important reaction between glycerol with oils or fats to produce MG. Glycerolysis reactions will run slowly without using catalyst. The existence of catalyst will make the reaction to run quickly and can take place under normal pressure and temperature conditions [12]. The reaction can be carried out in the presence of an acid catalyst or an alkaline catalyst. Reaction with an alkaline catalyst is usually faster [13].

The most common catalyst used in glycerolysis is base catalyst. glycerolysis reactions using a catalyst may use homogeneous or heterogeneous catalysts, each of them has deficiencies and advantages. Comparing to homogeneous catalysts (such as NaOH), heterogeneous catalysts (such as Ca/MgO) have several advantages, such as no production of soap, no need for neutralization and extraction, easier product separation and can be used repeatedly. The use of a heterogeneous catalyst may also be increased in activity by modification of the catalyst in the form of a composite or doping to a catalyst. Heterogeneous catalysts consist of two main components, namely as active sites (dopants) and buffers. The active site serves to increase the reaction rate and direct the reaction toward the desired product. The buffer which is generally a porous solid serves as a container for the distribution of the active site so that the catalyst has a larger surface area [14]. The mechanism of base catalyst in transesterification is shown in Fig. 2.

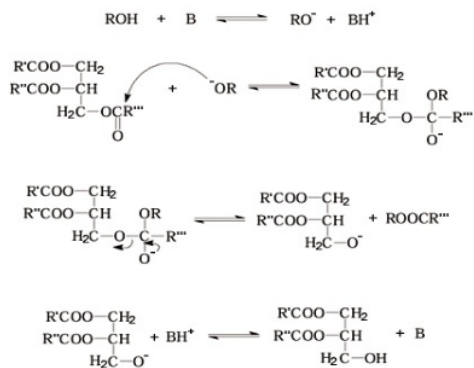


Fig. 2 Transesterification mechanism using base catalyst [15].

Basic strength of a solid surface is defined as the ability of the surface to convert an adsorbed neutral acid to its conjugate base *i.e.*, the ability of the surface to donate electron pair to an adsorbed acid [16]. Base sites in alkaline earth catalysts of oxides are generally caused by the presence of positive metal ion pairs (M^{2+}) which have the properties of Lewis acid and oxygen ions (O^{2-}) which have Bronsted base properties. The increasing of basic strength is proportional to the increasing of the activity of alkaline earth oxide metal catalysts as indicated by the increased yield of product [17].

Heterogeneous MgO base catalyst has been applied in the synthesis of MG from the reaction of glycerol with methyl oleate [18, 19]. Based on previous research [20], where MG synthesis by using Ca-doped MgO catalyst showed that Ca-doped MgO catalyst has the potential to develop its activity on glycerolysis reactions by modifying the structure, alkalinity and catalytic area of CaO/MgO. Verziu et al obtained that supported KF catalysts exhibited high catalytic activity for transesterification in which the biodiesel yield was more than 95% [21].

In this study, addition KF as support to KF/CaO-MgO catalyst was expected to obtain a higher yield of MG than other utilizations of heterogeneous catalyst. KF/CaO-MgO catalyst was prepared by impregnation method. The influences of the preparation conditions, such as calcination temperature and time, and weight KF addition on KF/CaO-MgO catalyst, on the activity of catalyst on MG yield were investigated. KF/CaO-MgO catalyst was characterized by X-Ray Diffraction, nitrogen adsorption and Tanabe method.

EXPERIMENTAL

Materials

The starting materials for Ca-MgO catalyst were magnesium acetate (Merck), calcium nitrate (Merck), citric acid (technical) and absolute ethanol (EtOH, technical 96%). For catalyst supporting, KF powder was used (Merck), while aquadest/deionized water was used for washing, then glycerol (Merck) and CPO as reactants for glycerolysis process.

KF/CaO-MgO catalyst preparation

Magnesium acetate, calcium nitrate, and citric acid compounds were weighed according to predetermined calculations and dissolved in 95% ethanol, the solution was stirred until clear color was obtained. All three solutions were mixed and distilled at 350 rpm until the sol-temperature reached 80°C. The formed gel was heated in an oven at 110°C until it was dried. The catalyst was then smoothed by using mortar and calcined it using furnace for 3 hours with a temperature range of 550°C. Impregnation of MgO-Ca with KF would be achieved by dissolving KF in deionized water then adding Ca-MgO before being stirred for 1 hour. Thereafter, the mixture was exposed to 140°C for 6 hours to remove the water absorbed onto the surface of the catalysts and calcined at various temperatures and time.

Characterization of catalyst structure by X-Ray Diffraction

XRD (Panalytical X'Pert Powder, Semarang State University) was used to characterize the structure of catalyst. XRD patterns were measured under the following conditions: $K\alpha$ ($\lambda = 1,5406 \text{ \AA}$) at 400 kV and 300 mA, $2\theta = 10 - 70^\circ$, step size 0.017, and step time 0,5 sec. At first, the sample was smoothed to a very fine powder, then placed on preparations and pressed. It was then placed on the sample holder and irradiated with X-rays. The results obtained (diffractogram) would be compared with the JCPDS standard for the compounds.

Characterization of specific surface area by using nitrogen adsorption

Analysis with Nitrogen Adsorption was carried out in the Integrated Chemical Engineering Laboratory, Diponegoro University, Semarang. Measurement of specific area was carried out by nitrogen adsorption method. Samples of 0.2 grams were treated with nitrogen gas with a flow rate of 30 cm^3/min at 200°C for 1 hour and cooled to adsorption and desorption of nitrogen at a temperature of 77°C.

Characterization of catalyst basicity by using Tanabe method

The Tanabe method was analyzed by Chemical Engineering Process Engineering Laboratory, Diponegoro University, Semarang. A gram of sample (catalyst) of 100 - 200 mesh was added into 100 ml erlenmeyer, before 20 mL of benzene and 1 mL of Bromthymol blue (BTB) indicator were added. After that, the solution was titrated with benzoate 0.1N.

Glycerolysis process and MG analysis

Palm oil, glycerol and catalyst (0,1%w KF/ w Ca-MgO) were mixed and stirred in a three necked bottom flask as shown in Fig 3 below. Then the reaction was carried out at 200°C and 700 rpm for 3 hours.

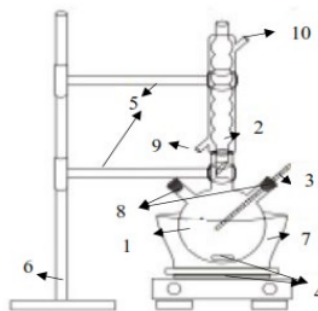


Fig. 3 Schematic diagram for Glycerolysis Process (1- three-necked round-bottomed flask, 2- condenser, 3- thermometer, 4- Magnetic stirrer + hotplate, 5- clamp, 6- stative, 7- oil bath, 8- glass cover, 9- water in, 10- water out.

The result analysis of the monoglycerides synthesis in the form of liquid product was carried out by using Gas Chromatography-Mass Spectrometry (GC-MS). This analysis was used to identify the monoglyceride components. The analysis was carried out with the condition of injector temperature, column temperature and with solvent used n-hexane and helium carrier gas with 1ml/min flow rate. The MS range used was 0 m/z up to 450 m/z.

RESULTS AND DISCUSSION

Characterization of KF/CaO-MgO catalyst and the influence to MG yield

The diffractogram in CaO gave intensity and has peaks at 2θ : 37.36°; 74.65° and 78.70°, MgO was seen at 2θ : 42.91° and 62.15°; and $\text{Ca}(\text{OH})_2$ has peaks at 2θ : 18.19°; 29.39°; 50.77° and 58.74° (JCPDS Data). When impregnated with a variation of % KF and calcination temperature variations were carried out on KF/CaO-MgO

catalyst, there was an additional new intensity for CaKF_3 crystals which had peaks at 2θ : 28.28° and 59.32° and MgKF_3 crystals with a peak of 2θ : 38.58° , as shown in Fig. 4 below.

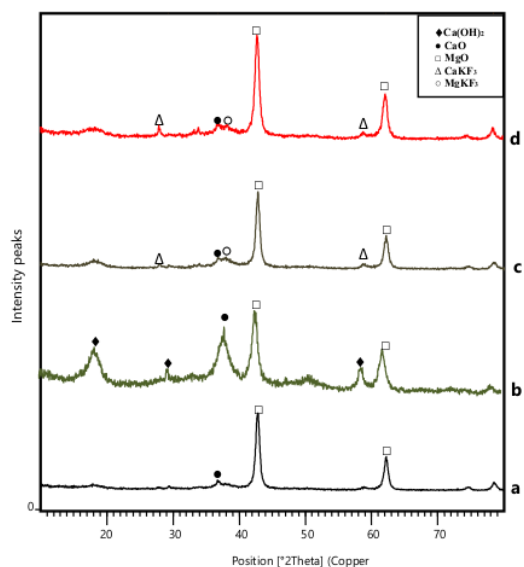


Fig.4 XRD pattern comparison between CaO-MgO catalyst (a); KF/CaO-MgO catalyst (2%w KF, 450°C, 2 h) (b); KF/CaO-MgO catalyst (2%w KF, 500°C, 2 h) (c); KF/CaO-MgO catalyst (2%w KF, 550°C, 2 h) (d)

Variations in KF support concentration, temperature and calcination time indicated differences in intensity and theta shift. When the calcination temperature was below 500°C , there was still $\text{Ca}(\text{OH})_2$ crystals and when the calcination temperature reached 500°C and up to 550°C , new peaks were formed in the form of crystals CaKF_3 and MgKF_3 were the active sites that formed due to the addition of KF as support and high temperature calcination and thus, increasing catalyst activity which influenced on the high yield of monoglycerides produced. Xuan's study confirmed that the addition of KF to heterogeneous catalysts and high calcination temperatures would help to produce crystals of CaKF_3 and MgKF_3 as active sites that could produce higher biodiesel yields due to high catalytic activity [22].

Characterization of specific surface area of KF/CaO-MgO catalyst

The specific surface area is shown in Table 2 below. Fig. 5 shows the correlation between specific area of the catalyst and MG yield, where at range $83\text{-}121\text{ m}^2/\text{g}$ of surface area, above 30% of MG yield was obtained and when the surface area was above $121\text{ m}^2/\text{g}$, the MG yields were getting lower. The higher MG yield was obtained by surface area value of $110\text{ m}^2/\text{g}$, this was closed to Wen (2010) result which obtained $109\text{ m}^2/\text{g}$ of catalyst surface area value that achieved 96.8% of biodiesel yield, meaning that the value of surface area was matched to produce high MG yield in the same condition of temperature and time of calcination [23]. From table 2, surface area which range $83\text{-}121\text{ m}^2/\text{g}$ was resulted by using calcination temperature above 500°C , which obtained high MG yield by 550°C of calcination temperature, but when the temperature reached 584°C , the MG yield was decreased, it was due to the fact that overheating resulted in the surface sintering and the reduction of specific surface area, which in turn led to the decreased of catalytic activity [24].

Table 2 Surface area value of KF/CaO-MgO catalyst.

Run	Calcination Temperature ($^\circ\text{C}$)	Calcination Time (hours)	%K F	Surface Area (m^2/g)	MG Yield (%)
1	450	2	2	132.456	22.85
2	450	2	4	144.566	26.52
3	450	4	2	152.036	24.31
4	450	4	4	141.128	21.78
5	550	2	2	110.924	47.96
6	550	2	4	84.285	41.65
7	550	4	2	92.362	39.16
8	550	4	4	83.521	36.13
9	416	3	3	154.384	13.98
10	584	3	3	85.481	32.94
11	500	1 h 19 min	3	119.706	44.75
12	500	4 h 40 min	3	98.005	31.78
13	500	3	1.32	121.128	43.36
14	500	3	4.68	94.447	38.58
15	500	3	3	105.946	40.28
16	500	3	3	106.623	35.30

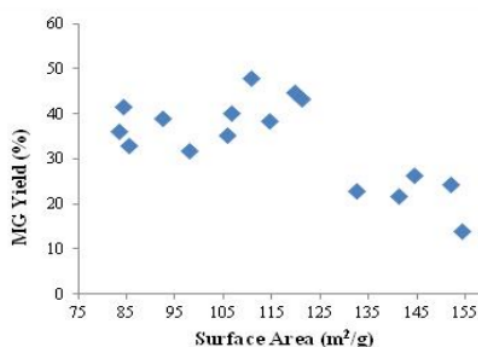


Fig. 5 Correlation between surface area and MG yield.

Conditional optimization of KF/CaO-MgO basicity

Optimization for the catalyst preparation was performed by central composite design of response surface methodology that is shown in Table 3.

Table 3 Basicity value of KF/CaO-MgO catalyst.

Run	Calcination Temp ($^\circ\text{C}$)	Calcination Time (hours)	% KF	Basicity (mmol/g)	MG Yield (%)
1	450		2	0.30	22.85
2	450	2	2	0.64	26.52
3	450	2	4	0.54	24.31
4	450	4	2	1.04	21.78
5	550	2	2	0.84	47.96
6	550	2	4	0.98	41.65
7	550	2	4	0.66	39.16
8	550	4	2	1.18	36.13
9	416	3	3	0.28	13.98
10	584	3	3	0.72	32.94
11	500	3	3	0.92	44.75
12	500	1 h 19 min	3	1.16	31.78
13	500	4 h 40 min	3	0.96	43.36
14	500	3	1.32	1.10	38.58
15	500	3	4.68	1.06	40.28
16	500	3	3	1.04	35.30
17	CaO-MgO	3	3	0.26	36.03

Table 3 shows that the increasing of weight KF obtained to higher catalyst basicity, and compared to unloaded support (CaO-MgO), the KF loaded catalysts have the higher catalyst basicity, indicating that loading KF onto the support material promoted the basic strengths and basicity of the catalysts [25]. The increasing of calcination temperature performed the higher catalyst basicity too, but when the

temperature reached 584°C, the catalyst basicity was lower, due to the changes in the catalyst composition which led to the increasing of catalyst basicity and the formation of new crystals namely CaKF_3 and MgKF_3 . According to Wen (2010), the addition of KF led to the formation of CaKF_3 which enhanced catalytic activity of the catalyst [23].

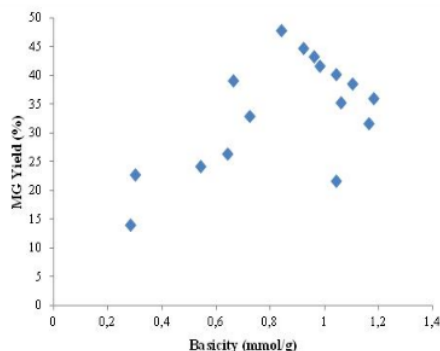


Fig. 6 Correlation between catalyst basicity and MG yield.

Figure 6 shows the correlation between catalyst basicity and MG yield, which optimal MG yield reached at 0.84 mmol/g of basicity and decreased when the catalyst basicity was higher. This was contrary to the greater the basicity, the higher the MG yield. According to Wen's study (2010), when the amount of KF was greater, the catalytic activity was decreased, since KF was supported on CaO, it was evenly distributed on CaO surface if the KF content was lower than a threshold with mono-molecular layer. When the KF content was higher than the threshold, it covered the activity sites, resulting in the decrease of catalytic ability. During the preparation of the solid catalyst, high temperature calcination favors the interaction between carrier and active component to form new crystal, activity sites. However, overheating can result in the surface sintering and the reduction of specific surface area, which in turn leads to the reduction in catalytic activity [23]. The current experiment showed that calcination at 550°C produced highly active catalyst.

Efficiency between CaO-MgO catalyst and KF/CaO-MgO catalyst

The comparison performance between CaO-MgO catalyst and KF/CaO-MgO catalyst is shown in Table 4, in which the loading KF onto the CaO-MgO promoted the basic strengths. By increasing the catalyst basicity, new active sites *i.e.* CaKF_3 and MgKF_3 were produced, that helped the increasing catalyst activity to produce higher MG yield.

Table 4 Comparison performance between CaO-MgO catalyst and KF/CaO-MgO catalyst.

Run	Catalyst	Basicity (mmol/g)	MG Yield (%)
1	CaO-MgO	0.84	36.03
2	KF/CaO-MgO	0.26	47.96

CONCLUSION

KF/CaO-MgO catalyst was prepared by impregnation method, resulting the active sites to produce a high MG yield of 49.76% for 2%w KF addition, at 550°C of calcination temperature and 2 hours of calcination time. It has a high specific surface area (110.924 m²/g) that was favorable for contact between catalyst and substrates which effectively improved the efficiency of glycerolysis. The high activity of the catalyst was described by the formation of KCaF_3 and MgKF_3 crystals as the active sites. However, further studies were required to

improve the MG yields by adding purification process in order to develop a commercially useful catalyst for the production of MG.

ACKNOWLEDGEMENT

The authors would like to gratitude to Ministry of Research, Technology, and Higher Education of Republic of Indonesia fiscal year 2018 for the financial support.

REFERENCES

- [1] Bomscheuer, U. T. 1995. Lipase - catalyzed syntheses of monoacylglycerols. *Enzyme and Microbial Technology*, 17:578-586.
- [2] Negi, D. S., Sobotka, F., Kimmel, T., Wozny, G., Schomacker, R. 2007. Glycerolysis of fatty acid methyl esters : Investigations in a batch reactor. *Journal of American Oil Chemist's Society*, 84:83-90.
- [3] David, L., Breeden, M. R. L. 2005. Ester - containing downhole drilling lubricating composition and processes therefore and therewith. *US Patent* 6.884.762.
- [4] Hough, D., Barclay, T., Drive, I., Merseyside, W. 1984. Fabric conditioning composition. *EPO*. 107479 A2.
- [5] Hans, G., Franke, B. D. R. 1996. Compositions for resilient biodegradable packaging material products. *US Patent* 5,512.
- [6] Rosen, M., Hall, L. K. 1982. Glycerol monostearate plastic lubricants. *US Patent* 4.363.891.
- [7] Shizuo, N., Yoshito, T., Yuuji, Y., Tomizou, K. 1984. Cement composition. *US Patent* 4.434.257.
- [8] BPS. 2016. *Statistik perdagangan luar negeri Indonesia*. Retrieved from <http://www.bps.go.id/publikasi.html>.
- [9] Ketaren, S. 1986. *Minyak dan lemak pangan*. UI Press. Jakarta.
- [10] McGee, H. 2004. *On food and cooking: The science and lore of the kitchen*. Scribner, edition. ISBN 978-0-684-80001-1.
- [11] Prakoso, T., Maria, M. S. 2007. Pembuatan monoglisericida. *Jurnal Teknik Kimia Indonesia*, 6: 689-697.
- [12] Mguni, L. L. 2012. *Biodiesel production over supported nano - magnesium oxide particles* (Unpublished Master Thesis). Retrieved from <https://ujcontent.uj.ac.za/vital/access/manager/Repository/>.
- [13] Kimmel, T. 2004. *Dissertation: Kinetic investigation of the base-catalyzed glycerolysis of fatty acid methyl ester*. Technischen Universitat Berlin, Berlin, Germany.
- [14] Pandiangan, K. D., Simanjuntak, W. 2013. *Sintesis katalis heterogen MgO-SiO₂ sekam padi dengan metode sol-gel dan aplikasinya pada reaksi transesterifikasi minyak kelapa*. *Seminar Nasional Sains & Teknologi V Lembaga Penelitian Universitas Lampung*. November: 516-524.
- [15] Schuchardt, U., Sercheli, R., Vargas, R.M. 1998. Transesterification of vegetable oils: a Review, *Journal of The Brazilian Chemical Society*, 9: 199-210.
- [16] Tanabe, K., Yamaguchi, T., Takeshita, T. (1968). Solid bases and their catalytic activity. *Journal of The Research Institute for Catalysis*, 16(1): 425-447.
- [17] Samik, Edianti, R., Prasetyoko, D. 2011. Review: Pengaruh kebasaaan dan luas permukaan katalis terhadap aktivitas katalis basa heterogen untuk produksi biodiesel. *Prosiding Seminar Nasional Kimia Unesa (pp. B-462 - B-467)*. Surabaya, Indonesia: Institut Teknologi Sepuluh November.
- [18] Heinrichs, B., Lambert, S., Job, N., Pirard, J. P., John, R. (Eds). 2007. *Catalysts preparation: Science and engineering*. Boca Roton: CRC Press.
- [19] Ferretti, C. A., Apestequia, C. R., Cosimo, J. I. D. 2011. MgO-based catalysts for monoglyceride synthesis from methyl oleate and glycerol: effect of Li promotion. *Applied Catalysis A: General*. 399:146-153.
- [20] Faishol, M. V. A. A. F. 2015. *Sintesis katalis heterogen Ca/MgO menggunakan metode sol gel untuk pembuatan monoglisericida* (Unpublished master thesis). Universitas Diponegoro, Semarang, Indonesia.
- [21] Verziu, M., Florea, M., Simon, S., Simon, V., Filip, P., Parvulescu, V. I., Handacre, C. 2009. Transesterification of vegetable oils on basic large mesoporous alumina supported alkaline fluorides - Evidences of the nature of the active site and catalytic performances. *Journal of Catalysis*, 263:56-66.
- [22] Xuan, J., Zheng, X., Hu, H. 2012. Active sites of supported KF catalysts for transesterification. *Catalysis Communication*, 28: 124-127.
- [23] Wen, L., Wang, Y., Lu, D., Hu, S., Han, H. 2010. Preparation of KF/CaO nanocatalyst and its application in biodiesel production from chinese tallow seed oil. *Fuel*, 89: 2267-2271.
- [24] Hu, S., Guan, Y., Wang, Y., Han, H. 2011. Nano-magnetic catalyst KF/CaO-Fe₃O₄ for biodiesel production, *Applied Energy*, 88: 2685-2690.

Preparation and characterization of KF/CaO-MgO catalyst for monoglycerides synthesis

ORIGINALITY REPORT

8%

SIMILARITY INDEX

5%

INTERNET SOURCES

5%

PUBLICATIONS

1%

STUDENT PAPERS

PRIMARY SOURCES

- | | | |
|---|---|------|
| 1 | Submitted to Institute of Research & Postgraduate Studies, Universiti Kuala Lumpur
Student Paper | <1 % |
| 2 | ml.scribd.com
Internet Source | <1 % |
| 3 | www.crc.rmutt.ac.th
Internet Source | <1 % |
| 4 | H. V. Lee, J. C. Juan, Y. H. Taufiq-Yap, P. S. Kong, N. A. Rahman. "Advancement in heterogeneous base catalyzed technology: An efficient production of biodiesel fuels", Journal of Renewable and Sustainable Energy, 2015
Publication | <1 % |
| 5 | Submitted to University of Babylon
Student Paper | <1 % |
| 6 | Li, Hui, Shengli Niu, Chunmei Lu, Mengqi Liu, and Mengjia Huo. "Transesterification catalyzed by industrial waste—Lime mud | <1 % |

doped with potassium fluoride and the kinetic calculation", Energy Conversion and Management, 2014.

Publication

7

www.researchgate.net

Internet Source

<1 %

8

Yanhong Zu, Jianyuan Tang, Wanchun Zhu, Min Zhang, Gang Liu, Yan Liu, Wenxiang Zhang, Mingjun Jia. "Graphite oxide-supported CaO catalysts for transesterification of soybean oil with methanol", Bioresource Technology, 2011

Publication

<1 %

9

Hu, Shengyang, Libai Wen, Yun Wang, Xincheng Zheng, and Heyou Han. "Gas-liquid countercurrent integration process for continuous biodiesel production using a microporous solid base KF/CaO as catalyst", Bioresource Technology, 2012.

Publication

<1 %

10

Ruili Song, Dongmei Tong, Jinqiang Tang, Changwei Hu. "Effect of Composition on the Structure and Catalytic Properties of KF/Mg-La Solid Base Catalysts for Biodiesel Synthesis via Transesterification of Cottonseed Oil", Energy & Fuels, 2011

Publication

<1 %

11

Internet Source

<1 %

12

Guomin Xiao, Lijing Gao. "Chapter 3 First Generation Biodiesel", IntechOpen, 2011

Publication

<1 %

13

elib.uni-stuttgart.de

Internet Source

<1 %

14

pelagiaresearchlibrary.com

Internet Source

<1 %

15

www.futuremedicine.com

Internet Source

<1 %

16

Klinkesorn, U.. "Chemical transesterification of tuna oil to enriched omega-3 polyunsaturated fatty acids", Food Chemistry, 200409

Publication

<1 %

17

L. Y. Zhang, Y. Z. Wang, G. T. Wei, Z. Y. Li, H. N. Huang. "Biodiesel preparation from Jatropha oil catalyzed by KF/Red mud catalyst", Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 2016

Publication

<1 %

18

eprints.undip.ac.id

Internet Source

<1 %

19

journal.ugm.ac.id

Internet Source

<1 %

20

www.coursehero.com

Internet Source

<1 %

21

www.springerprofessional.de

Internet Source

<1 %

22

Corma, A.. "Lewis and Bronsted basic active sites on solid catalysts and their role in the synthesis of monoglycerides", Journal of Catalysis, 20050910

Publication

<1 %

23

e-space.mmu.ac.uk

Internet Source

<1 %

24

G B Pradana, K B Prabowo, R P Hastuti, M Djaeni, A Prasetyaningrum. "Seaweed Drying Process Using Tray Dryer with Dehumidified Air System to Increase Efficiency of Energy and Quality Product", IOP Conference Series: Earth and Environmental Science, 2019

Publication

<1 %

Exclude quotes Off

Exclude matches Off

Exclude bibliography On

Preparation and characterization of KF/CaO-MgO catalyst for monoglycerides synthesisawati Oktaviany

GRADEMARK REPORT

FINAL GRADE

/0

GENERAL COMMENTS

Instructor

PAGE 1

PAGE 2

PAGE 3

PAGE 4
