BAB V

KESIMPULAN DAN SARAN

V.1 Kesimpulan

Berdasarkan dari penelitian yang telah dilakukan, katalis CaO-GO memiliki aktivitas katalitik yang tinggi pada proses transesterifikasi CPO. Hasil penelitian ini menunjukan hasil terbaik dari katalis CaO-GO dengan perbandingan 1:1 dan 2:1 untuk proses transesterifikasi adalahpada persen berat katalis 8% di perbandingan minyak : metanol 1:15. Dengan perbandingan 1:1 katalis CaO-GO dapat menghasilkan yield sebesar 95,02% dengan kemurnian 86,47% dan perbandingan 2:1 dapat menghasilkan yield sebesar 93,47% dengan kemurnian 47,52%. Selain itu, katalis CaO-GO juga digunakan untuk regenerasi sebanyak 5 kali pada CPO. Hasil yield yang didapatkan pada perbandingan katalis 1:1 dan 2:1 untuk regenerasi kelima pada CPO sebesar 69,12% dan 65,31% . Dari Analisa XRD yang sudah dilakukan, katalis yang digunakkan untuk proses pembuatan biodiesel mengandung GO(*acidic site*) dan CaO(*Basic site*) sehingga dapat disimpulkan bahwa katalis CaO-GO mempunyai karakteristik bifungsional.

V.2 Saran

Kedepannya penelitian dapat dilakukan studi lebih lanjut untuk sintesis katalis CaO-GO agar dapat mengetahui bentuk dan komposisi partikel melalui analisa SEM-EDX. Karakterisasi FTIR juga diperlukan untuk menganalisis gugus fungsi biodiesel. Selain itu, penelitian selanjutnya dapat berfokus dalam mempelajari dan mendalami kondisi optimum pada rasio mol minyak:metanol dalam proses transesterifikasi dengan menggunakan minyak goreng.

DAFTAR PUSTAKA

[1] I. N. Finahari *et al 2018.*, “Gas CO2 dan Polutan Radioaktif dari PLTU Batubara”.

[2] A. Setiawan, D. P. Tua, and M. K. E. Husin, “Pengaruh konsumsi bahan bakar fosilterhadap produk domestik bruto Indonesia dan hubungan timbal balik di antara keduanya,” *J. Teknol. Miner. dan Batubara*, vol. 15, no. 3, pp. 213–223, 2019, doi:10.30556/jtmb.vol15.no3.2019.931.

[3] D. Gunawan Prasetyo *et al.*, “Review Artikel KATALIS KALSIUM OKSIDA (CaO) BERBASIS BIO UNTUK PRODUKSI BIODIESEL BIO-BASED CALCIUM OXIDE (CaO) CATALYST FOR BIODIESEL PRODUCTION,” *J. Kinet.*, vol. 12, no. 03, pp. 56–60, 2021, [Online]. Available: https://jurnal.polsri.ac.id/index.php/kimia/index56

[4] S. Oko and M. Feri, “Pengembangan Katalis CaO dari Cangkang Telur Ayam dengan Impregnasi KOH dan Aplikasinya Terhadap Pembuatan Biodiesel dari Minyak Jarak,”*J. Teknol. Univ. Muhammadiyah Jakarta*, vol. 11, no. 2, pp. 103–110, 2019, [Online]. Available: https://jurnal.umj.ac.id/index.php/jurtek/article/view/3967/3283

[5] M. Zamhari *et al.*, “PEMBUATAN KATALIS BERBASIS KARBON AKTIF DARI TEMPURUNG KELAPA (Cocos nucifera) DIIMPREGNASI KOH PADA REAKSI TRANSESTERIFIKASI SINTESIS BIODIESEL CATALYST SHYNTHESIS FROMACTIVATED CARBON

OF COCONUT SHELL (Cocos nucifera) IMPREGNATEDPOTASSIUM HYDROXIDEIN T," *J. Kinet.*, vol. 12, no. 01, pp. 23–31, 2021, [Online]. Available: https://jurnal.polsri.ac.id/index.php/kimia/index

[6] F. Catania *et al.*, "A review on recent advancements of graphene and graphene-related materials in biological applications," *Appl. Sci.*, vol. 11, no. 2, pp. 1–21, 2021, doi: 10.3390/app11020614.

[7] J. D. McCurry, "GC Analysis of Total Fatty Acid Methyl Esters (FAME) and Methyl Linolenate in Biodiesel Using the Revised EN14103 : 2011 Method," *Agil. Technol.*, p.5, 2011.

[8] Y. Zu *et al.*, "Graphite oxide-supported CaO catalysts for transesterification of soy bean oil with methanol," *Bioresour. Technol.*, vol. 102, no. 19, pp. 8939-8944, 2011, doi: 10.1016/j.biortech.2011.07.032.

[9] M. Guo, W. Jiang, J. Ding, and J. Lu, "Highly active and recyclable CuO/ZnO as photocatalyst for transesterification of waste cooking oil to biodiesel and the kinetics,"

Fuel, vol. 315, p. 123254, May 2022, doi: 10.1016/J.FUEL.2022.123254.

[10] T. C. Dos Santos, E. C. S. Santos, J. P. Dias, J. Barreto, F. L. Stavale, and C. M. Ronconi, "Reduced graphene oxide as an excellent platform to produce a stable Brønsted acid catalyst for biodiesel production," *Fuel*, vol. 256, p. 115793, Nov. 2019,doi: 10.1016/J.FUEL.2019.115793.

[11] B. H. Jume, M. A. Gabris, H. Rashidi Nodeh, S. Rezania, and

J. Cho, “Biodiesel production from waste cooking oil using a novel heterogeneous catalyst based on graphene oxide doped metal oxide nanoparticles,” *Renew. Energy*, vol. 162, pp. 2182–2189, 2020, doi: 10.1016/j.renene.2020.10.046.

[12] S. Rangga, S. Arita, and K. Attaso, “Making of Palm Oil into Biodiesel Catalyzed byCaO aided by Microwave Heating,” *5th Sriwij. Int. Semin. Energy Environ. Sci. Technol.*, 2014.

[13] A. C. Pinto *et al.*, “Biodiesel: An overview,” *J. Braz. Chem. Soc.*, vol. 16, no. 6 B, pp. 1313–1330, 2005, doi: 10.1590/S0103-50532005000800003.

[14] M. M. Azam, A. Waris, and N. M. Nahar, “Prospects and potential of fatty acid methylesters of some non-traditional seed oils for use as biodiesel in India,” *Biomass and Bioenergy*, vol. 29, no. 4, pp. 293–302, Oct. 2005, doi: 10.1016/J.BIOMBIOE.2005.05.001.

[15] R. A. Ferrari, V. Da S. Oliveira, and A. Scabio, “Oxidative stability of biodiesel from soybean oil fatty acid ethyl esters,” *Sci. Agric.*, vol. 62, no. 3, pp. 291–295, May 2005, doi: 10.1590/S0103-90162005000300014.

[16] R. R. S. Zuhri, “Pembuatan Biodiesel Berbasis CPO (Crude Palm Oil) MenggunakanK-Silika Sebagai Katalis Heterogen,” no. September, 2018.

[17] K. Suppalakpanya, S. Ratanawilai, R. Nikhom, and C. Tongurai, “Production of ethylester from crude palm oil by two-step reaction using continuous microwave system,”

Songklanakarin J. Sci. Technol., vol. 33, no. 1, pp. 79–86, 2011.

[18] A. Guldhe, B. Singh, T. Mutanda, K. Permaul, and F. Bux, "Advances in synthesis of biodiesel via enzyme catalysis: Novel and sustainable approaches," *Renew. Sustain. Energy Rev.*, vol. 41, pp. 1447–1464, Jan. 2015, doi: 10.1016/J.RSER.2014.09.035.

[19] R. L. (Richard L. Myers, "The basics of physics," p. 365, 2006.

[20] J. Clohessy and W. Kwapinski, "Carbon-based catalysts for biodiesel production-Areview," *Appl. Sci.*, vol. 10, no. 3, pp. 1–17, 2020, doi: 10.3390/app10030918.

[21] A. Blanco, A. García-Abuín, D. Gómez-Díaz, and J. M. Navaza, "Density, Speed of Sound, Viscosity, and Surface Tension of Dimethylethylenediamine + Water and (Ethanolamine + Dimethylethanolamine) + Water from T = (293.15 to 323.15) K," *J.Chem. Eng. Data*, vol. 61, no. 1, pp. 188–194, Jan. 2016, doi: 10.1021/ACS.JCED.5B00447/ASSET/IMAGES/MEDIUM/JE-2015- 00447G_0004.GIF.

[22] "Pembuatan Biodiesel dari Treated Waste Cooking Oil (TWCO) dengan Katalis ZeolitAlam dan CaO yang Berasal dari Cangkang Telur Ayam: Pengaruh Berat Katalis dan Suhu Reaksi."

[23] A. Islam, Y. H. Taufiq-Yap, C. M. Chu, E. S. Chan, and P. Ravindra, "Studies on design of heterogeneous catalysts for biodiesel production," *Process Saf. Environ.Prot.*, vol. 91, no.

1–2, pp. 131–144, Jan. 2013, doi: 10.1016/J.PSEP.2012.01.002.

[24] D. W. Lee, Y. M. Park, and K. Y. Lee, "Heterogeneous base catalysts for transesterification in biodiesel synthesis," *Catal. Surv. From Asia*, vol. 13, no. 2, pp. 63–77, 2009, doi: 10.1007/s10563-009-9068-6.

[25] R. Poreddy, C. Engelbrekt, and A. Riisager, "Copper oxide as efficient catalyst for oxidative dehydrogenation of alcohols with air," *Catal. Sci. Technol.*, vol. 5, no. 4, pp.2467–2477, Mar. 2015, doi: 10.1039/C4CY01622J.

[26] I. M. Rizwanul Fattah *et al.*, "State of the Art of Catalysts for Biodiesel Production,"*Front. Energy Res.*, vol. 8, no. June, pp. 1–17, 2020, doi: 10.3389/fenrg.2020.00101.

[27] Z. Zhou, Y. Li, S. Yao, and H. Yan, "Preparation of calcium carbonate@graphene oxide core-shell microspheres in ethylene glycol for drug delivery," *Ceram. Int.*, vol.42, no. 2, pp. 2281–2288, 2016, doi: 10.1016/j.ceramint.2015.10.022.

[28] N. Pranyoto *et al.*, "Facile Synthesis of Silane-Modified Mixed Metal Oxide as Catalyst in Transesterification Processes," *Nanomaterials*, vol. 12, no. 2, 2022, doi: 10.3390/nano12020245.

[29] R. Z. Octavia, "PEMBUATAN DAN UJI KUALITAS BAHAN BAKARALTERNATIF (BIODIESEL) DARI MINYAK KELAPA (Cocos nucifera

),” Fak. Sains Dan Teknol. Univ. Islam Negeri (Uin) Alauddin. Makassar, pp. 1–82,2011.

[30] Santos, S., Nobre, L., Gomes J., Puna, J., Fereeira, R.Q., dan Bordado, J.. 2019. Soybean Oil Transesterification for Biodiesel Production with Micro-Structured Calcium Oxide (CaO) from Natural Waste Materials as a Heterogeneous Catalyst,Energies, 12(4670), 1-10.

[31] Pandit, P.R., dan Fulekar, M.H. 2019. Biodiesel production from microalgal biomassusing CaO catalyst synthesized from natural waste material, Renewable Energy, 136,837-845.

[32] Kojima, Y., dan Takai, S., 2019. Transesterification of vegetable oil with methanol using solid base catalyst of calcium oxide under ultrasonication, Chemical Engineering & Processing : Process Intensification, 135, 101-106.

[33] Borah, M.J., Das, A., Das, V., Bhuyan, N. & Deka, D. 2019. Transesterification of waste cooking oil for biodiesel production catalyzed by Zn substituted waste egg shell derived CaO nanocatalyst. Fuel. 242: 345–354.

[34] Khatibi, M., Khorasheh, F., dan Larimi, A. 2021. Biodiesel production via transesterification of canola oil in the presence of NaeK doped CaO derived from calcined eggshell, Renewable Energy, 163, 1626-1636.

[35] Manaf, I. S. A. Et al. (2019) ‘A review for key challenges of the development of biodiesel industry’, Energy

Conversion and Management, 185(November 2018), pp. 508–517.

[36] Jookjantra, Kittichai dan Wongwuttanasatian, Tanakorn. 2017. Optimisation of biodiesel production from refined palm oil with heterogeneous CaO catalyst using pulse ultrasonic waves under a vacuum condition, Energy Conversion and Management, 154, 1-10.

[37] Aziz, Isalmi, Nurbayti, Siti Ulum, Badrul. 2012. Pembuatan produk biodiesel dariMinyak Goreng Bekas dengan Cara Esterifikasi dan Transesterifikasi

[38] Ali, Basit Yusup, Suzana Quitain, Armando T Sahban, Mohamad Nik, RuzaimahKamil, M Kida, Tetsuya. 2018 Synthesis of novel graphene oxide / bentonite bi- functional heterogeneous catalyst for one-pot esterification and transesterification reactions

[39] N. Sutanto and S. Samik, "Artikel Review : Pemanfaatan Katalis CaO Untuk Pembuatan Biodiesel Menggunakan Metode Transesterifikasi dari Non Edible Oil Article Review : Utilization of CaO Catalyst to Produce Biodiesel by Transesterification Method from Non-Edible Oil," *Univ. Negeri Surabaya Jur. Kim.*,pp. 46–55, 2021.

[40] Atkins,2017 *Physical chemistry*,chap. 9 Chemical Equilibrium vol. 272, no. 1. 1961. doi: 10.1016/0016-0032(61)90671-8.

[41] Sulaiman, N.F., Ramly, N.I., Abd Mubin, M.H., and Lee,

S.L., “Transition metal oxide (NiO, CuO, ZnO)-doped calcium oxide catalysts derived from eggshells for the transesterification of refined waste cooking oil,” RSC Adv. 11(35):21781–21795, 2021, doi:10.1039/d1ra02076e.

[42] M. Ramli *et al.*, “Nanoparticle fabrication of calcium oxide (CaO) mediated by the extract of red dragon fruit peels (Hylocereus Polyrhizus) and its application as inorganic-anti-microorganism materials,” *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 509,no. 1, pp. 13–18, 2019, doi: 10.1088/1757-899X/509/1/012090.

[43] N. S. Lani, N. Ngadi, M. Jusoh, Z. Mohamad, and Z. Y. Zakaria, “Outstanding performance of waste chicken eggshell derived CaO as a green catalyst in biodiesel production: Optimization of calcination conditions,” *J. Phys. Conf. Ser.*, vol. 1349, no.1, 2019, doi: 10.1088/1742-6596/1349/1/012051.

[44] M. Handayani *et al.*, “Fabrication of Graphene Oxide/Calcium Carbonate/Chitosan Nanocomposite Film with Enhanced Mechanical Properties,” *IOP Conf. Ser. Mater.Sci. Eng.*, vol. 578, no. 1, 2019, doi: 10.1088/1757-899X/578/1/012073.

[45] R. Siburian, H. Sihotang, S. Lumban Raja, M. Supeno, and C. Simanjuntak, “New route to synthesize of graphene nano sheets,” *Orient. J. Chem.*, vol. 34, no. 1, pp. 182–187, 2018, doi: 10.13005/ojc/340120.

[46] A. Santoso, M. Rizky, S. Sumari, A. Ricky Wijaya, R.

Retnosari, and M. Roy Asrori, “Pengaruh Jenis Alkohol dalam Trans-Esterifikasi Minyak Sawit (CPO) dengan Katalis Heterogen CaO-MgO,” *Univ. Negeri Malang Jl. Semarang*, vol. 5, no. 1, p. 65145, 2021.

[47] T. Pangestu *et al.*, “The synthesis of biodiesel using copper based metal-organic framework as a catalyst,” *J. Environ. Chem. Eng.*, vol. 7, no. 4, p. 103277, 2019, doi: 10.1016/j.jece.2019.103277.

[48] Ali Mubarak *et al.*, May 2023“Qualitative Analyses of Thin Film-Based Materials Validating New Structures of Atoms” DOI:10.13140/RG.2.2.27720.65287/3