



DAFTAR PUSTAKA

- Abdoulmoumine, N., 2010, Sulfate and Hydroxide Supported on Zirconium Oxide Catalysts for Biodiesel Production, *Tesis*, Faculty of the Virginia Polytechnic Institute and State University, Virginia.
- Abidin, S.Z., Haigh, K.F., dan Saha, B., 2012, Esterification of Free Fatty Acids in Used Cooking Oil Using Ion-Exchange Resins as Catalysts: An Efficient Pretreatment Method for Biodiesel Feedstock, *Ind. Eng. Chem. Res.*, 51, 14653-14664
- Adhiatma, A., Ansshory, C.P., Purwanto, A., dan Ciptonugroho, W., 2012, The Enhancement of Waste Cooking Oil Esterification Catalyzed by Sulfated Zirconia and Assisted by The Addition of Silica Gel, *Proceeding of 19th Regional Symposium on Chemical Engineering*, 7-8 November, Bali.
- Aguilaa, G., Salinasb, D., Jiménezc, R., Guerrerod, S., dan Arayae, P., 2016, ZrO₂-Supported Alkali Metal (Li, Na, K) Catalysts for Biodiesel Production, *J. Chil. Chem. Soc.*, 61, 3233-3238.
- Agus, A. dan Zahrul, M., 2019, Small-Scale Production of Biodiesel Through Transesterification Process of Waste or Used Cooking Oil, *Earth Environ. Sci.*, 245, 012-047.
- Anantapinitwatna, A., Ngaosuwan, K., Kiatkittipon, W., Wongsawaeng, D., Assabumrungrat, S., 2019, Effect of Water Content in Waste Cooking Oil on Biodiesel Production via Ester-transesterification in a Single Reactive Distillation, *Mater. Sci. Eng.*, 559, 012-014.
- Arata, K. dan Hino, M., 1990, Solid Catalyst Treated with Anion: XVII. Benzoylation of Toluene with Benzoyl Chloride and Benzoic Anhydride Catalysed by Solid Superacid of Sulfate-supporte Alumina, *Appl. Catal.*, 59, 197-204.
- Arita, S., Dara, M.B., dan Irawan, J., 2008, Pembuatan Metil Ester Asam Lemak dari CPO *off grade* dengan Metode Esterifikasi-Transesterifikasi, *J. Teknik Kimia*, 2, 58-65.
- Barone, J. R., 2007, FT-IR Analysis of Oil Feedstock and Biodiesel Quality, *Conf. Prosceeding in ACS National Meeting Book of Abstracts*, ISSN-00657727.
- Colombo, K., Ender, L., Santos, M.M., Barros, A.A.C, 2019, Production of Biodiesel from Soybean Oil and Methanol, Catalyzed by Calcium Oxide in A Recycle Reactor, *S. Afr. J. Chem. Eng.*, 28, 19–25.
- Coma, A. 1995, Inorganic Solid Acids and Their Use in Acid-Catalyzed Hydrocarbon Reactions, *Chem. Rev.*, 95, 559-614.
- de Jesus, A.A.A., de Santana, S.D.F., de Oliveira, J.A., de Deus, M.S., da Silva, M.G., Franceschi, E., da Silva, E.S.M., Dariva, C., Mathematical Modeling



and Experimental Esterification at Supercritical Conditions for Biodiesel Production in A Tubular Reactor, *Energy Convers. Manag.*, 171, 1697-1703.

Dehkordi, A.M. dan Ghasemi, M., 2012, Transesterification of Waste Cooking Oil to Biodiesel Using Ca and Zr Mixed Oxides as Heterogeneous Base Catalysts, *Fuel Process Technol.*, 234, 81-93.

Donnell, S. O., Demshemino, I., Yahaya, M., Okoro, L., dan Way, L.Z., 2013, A Review on The Spectroscopic Analyses of Biodiesel, *European Int. J. Sci. Tech.*, 2, 137-146.

Du, L., Ding, S., Li, Z., Lv, E., Lu, J., dan Ding, J., 2018, Transesterification of Castor Oil to Biodiesel Using NaY Zeolite-Supported La₂O₃ Catalysts, *Energy Convers. Manag.*, 173, 728–734.

Essamlali, Y., Amadine, O., Larzek, M., Len, C., dan Zahouily, M., 2017, Sodium Modified Hydroxyapatite: Highly Efficient and Stable Solid-Base Catalyst for Biodiesel Production, *Energy Convers. Manag.*, 149, 355–367.

Fadhil, A.B., Al-Tikrity, E.T.B., dan Khalaf, A.M., 2018, Transesterification of Non-edible Oils over Potassium Acetate Impregnated CaO Solid Base Catalyst, *Fuel*, 234, 81-93.

Fatimah, I., Taushiyah, A., Najah, F.B., dan Azmi, U., 2017, ZrO₂/Bamboo Leaves Ash (BLA) Catalyst in Biodiesel Conversion of Rice Bran Oil, *IOP Conf. Ser., Mater. Sci. Eng.*, 349, 012-027.

Fu, B., Gao, L., Niu, L., Wei, R., dan Xiao, G., 2009, Biodiesel from Waste Cooking Oil via Hetetogeneous Superacid Catalyst SO₄²⁻/ZrO₂, *Energy Fuels*, 23, 569-572.

Hartono, R., Wijanarko, A., dan Hermansyah, H., 2018, Synthesis of Biodiesel Using Local Natural Zeolite as Heterogeneous Anion Exchange Catalyst, *IOP Conf. Ser., Mater. Sci. Eng.*, 345, 002-012.

Hauli, L., Wijaya, K., dan Armunanto, R., 2018, Preparation and Characterization of Sulfated Zirconia from a Commercial Zirconia Nanopowder, *Orient. J. Chem.*, 34, 1559-1564.

Kalsi, P.S, 2007, *Spectroscopy of Organic Compounds*, Edisi Ke-6, ISBN: 81-224-1543-1, New Age International (P) Ltd., New Delhi.

Kaneko, K., 1994, Determination of Pore Size and Pore Size Distribution 1. Adsorbents and Catalysts, *J. Membr. Sci.*, 96, 59-89.

Kaur, N. and Ali, A., 2014, Kinetics and Reusability of Zr/CaO as Heterogeneous Catalyst for The Ethanolysis and Methanolysis of Jatophha Crucas Oil, *Fuel Process Technol.*, 119, 173-184.



- Knothe, G., 2000, Monitoring A Progressing Transesterification Reaction by Fiber-Optic Near Infrared Spectroscopy with Correlation to ¹H-Nuclear Magnetic Resonance Spectroscopy, *J. Am. Oil Chem. Soc.*, 77, 489-493.
- Kouzu, M., Kasuno, T., Tajika, M., Sugimoto, Y., Yamanaka, S., and Hidaka, J., 2008, Calcium Oxide as A Solid Base Catalyst for Transesterification of Soybean Oil and Its Application to Biodiesel Production, *J. Fuel*, 87, 2798-2806.
- Kumar, D. dan Ali, A., 2013, Transesterification of Low Quality Triglycerides over Zn/CaO as Heterogeneous Catalyst: Kinetics and Reusability Studies, *Energy and Fuels*, 27, 3758-3768.
- Lassi, S.Y.E., 2015, Sintesis Biodiesel dari Minyak Goreng Bekas dengan Bantuan Gelombang Mikro Terkatalisis SO₄/ZrO₂ dan KOH/ZrO₂, *Tesis*, Jurusan Kimia FMIPA UGM, Yogyakarta.
- Li, E., Xu, Z.P., dan Rudolph, V., MgCoAl-LDH Derived Heterogeneous Catalysts for The Ethanol Transesterification of Canola Oil to Biodiesel, *Appl. Catal., B*, 88, 42–49.
- Murad, A.M., Vianna, G.R., Machado, A.M., Da Cunha, N.B., Coelho, C.M., dan Lacerda, V.A.M., 2014, Mass Spectrometry Characterisation of Fatty Acids from Metabolically Engineered Soybean Seeds, *Anal. Bioanal. Chem.*, 406, 2873–2883.
- Nasseri, M.A., Alavi, S.A., Kazemnejadi, M., dan Allahresani, A., 2019, The CuFe₂O₄@SiO₂@ZrO₂/SO₄²⁻/Cu Nanoparticles: An Efficient Magnetically Recyclable Multifunctional Lewis/Brønsted Acid Nanocatalyst for The Ligand- and Pd-free Sonogashira Cross-coupling Reaction in Water, *RSC Adv.*, 9, 20749–20759.
- Novilla, A., Nursidika, P., dan Mahargyani, W., 2017, Komposisi Asam Lemak Minyak Kelapa Murni (*Virgin Coconut Oil*) yang Berpotensi Sebagai Anti Kandidiasis, *EduChemia*, 2, 2502-4787.
- Nurbayti, A.S. dan Ulum, B., 2019, Esterifikasi Asam Lemak Bebas dari Minyak Goreng Bekas, *Valensi*, 2, 384–388.
- Omar, W.N.N.W. dan Amin, N.A.S., 2011, Optimization of Heterogeneous Biodiesel Production from Waste Cooking Palm Oil via Response Surface Methodology, *Biom. Bioenergy*, 35, 1329-1338.
- Ore, M.S.L, 2019, Sintesis dan Karakterisasi Katalis Asam SO₄/ZrO₂ dan Katalis Basa Zr/CaO serta Aplikasinya untuk Konversi Minyak Kelapa Kualitas Rendah Menjadi Biodiesel, *Tesis*, Jurusan Kimia FMIPA UGM, Yogyakarta.
- Patel, A., Brahmkhatri, V., and Singh, N., 2013, Biodiesel Production by Esterification of Free Fatty Acid over Sulfated Zirconia, *Renew. Energy*, 51, 227-233.



- Patil, P. dan Pratap, A., 2016, Preparation of Zirconia Supported Basic Nanocatalyst: A Physicochemical and Kinetic Study of Biodiesel Production from Soybean Oil, *J. Oleo Sci.*, 65, 331-337.
- Petchmala, A., Laosiripojana, N., Jongsomjit, B., Goto, M., Panpranot, J., Mekasuwanumrong, O., dan Shotipruk, A., 2010, Transesterification of Palm Oil and Esterification of Palm Fatty Acid in Near- and Super-Critical Methanol with SO₄/ZrO₂ Catalyst, *Fuel*, 89, 2387-2392.
- Rabee, A.I.M., Mekhemer, G.A.H., Osatiashiani, A., Isaacs, M.A., Lee, A.F., Wilson, K., dan Zaki, M.I., 2017, Acidity-Reactivity Relationships in Catalytic Esterification over Ammonium Sulfate-Derived Sulfated Zirconia, *Catalysts*, 7, 204.
- Rachmat, A., Trisunaryanti, W., dan Wijaya, K., 2017, Synthesis and Characterization of Sulfated Zirconia Mesopore and Its Application on Lauric Acid Esterification, *J Renew Sustain Ener.*, 13, 2-9.
- Rahman, N.J.A., Ramli1, A., Jumbri, K., dan Uemura, Y., 2018, Influence of Preparation Methods on Physicochemical Properties of Zirconia for Transesterification of *Nannochloropsis Oculata* Microalga's Oil, *J. Phys.: Conf. Ser.*, 1123, 012-053.
- Rocha, P.D., Oliveira, L.S., dan Franca, A.S., 2019, Sulfonated Activated Carbon from Corn Cobs as Heterogeneous Catalysts for Biodiesel Production Using Microwave-Assisted Transesterification, *Renew. Energy*, 143, 1710-1716.
- Rothenberg, G., Kiss, A.A., dan Dimian, A.C., 2006, Solid Acid Catalysts for Biodiesel Production – Towards Sustainable Energy, *Adv. Synth. Catal.*, 348, 75-81.
- Sakai, T., Kawashima, A., dan Koshikawa, T., 2009, Economic Assessment of Batch Biodiesel Production Processes Using Homogeneous and Heterogeneous Alkali Catalysts, *Bioresour. Technol.*, 100, 3268-3276.
- Santos, R.C.M, Gurgel, P.C., Pereira, N.S., Breves, R.A., Matos, P.R.R., Silva, L.P., Sales, M.J.A., Lopes, R.d.V.V, 2019, Ethyl Esters Obtained from Pequi and Macaúba Oils by Transesterification with Homogeneous Acid Catalysis, *Fuel*, 259, 116-206.
- Saravanan, K., Tyagi, B., dan Bajaj, H.C., 2012, Esterification of Caprylic Acid with Alcohol over Nano-Crystalline Sulfated Zirconia, *J. Sol-Gel Sci. Technol.*, 62, 13-17
- Setyaningsih, S., 2019, Sintesis Katalis Asam Padat SO₄/ZrO₂ dan Basa Padat Na₂O/ZrO₂ secara Hidrotermal dan Aplikasinya untuk Pembuatan Biodiesel dari *Low Grade Crude Palm Oil*, Tesis, Jurusan Kimia FMIPA UGM, Yogyakarta.



- Shah, K.A., Parikh, J.K., dan Maheria, K.C., 2014, Optimization Studies and Chemical Kinetics of Silica Sulfuric Acid-Catalyzed Biodiesel Synthesis from Waste Cooking Oil, *BioEnergy Res.*, 7, 206-216.
- Shi, G., Yu, F., Wang, Y., Pan, D., Wang, H., dan Li, R., 2016, A Novel One-Pot Synthesis of Tetragonal Sulfated Zirconia Catalyst with High Activity for Biodiesel Production from The Transesterification of Soybean Oil, *Renew. Energy*, 92, 22-29.
- Shohaimi, N.A.M. dan Marodzi, F.N.S., 2017, Transesterification of Waste Cooking Oil in Biodiesel Production Utilizing CaO/Al₂O₃ Heterogeneous Catalyst, *Malaysian J. Anal. Sci.*, 22, 157-165.
- Sohn, J.R. dan Seo, D.H., 2003, Preparation of New Solid Superacid Catalyst, Zirconium Sulfate Supported on γ -Alumina and Activity for Acid Catalysis, *Catal. Today*, 87, 219-226.
- Sohn, J.R., Lee, S.H., and Lim, J.S., 2006, New Solid Superacid Catalyst Prepared by Doping ZrO₂ with Ce and Modifying with Sulfate and Its Catalytic Activity for Acid Catalysis, *Catal. Today*, 116, 143–150.
- Soldi, R.A., Oliveira, A.R.S., Ramos, L.P., dan Oliveira, M.A.F.C., 2009, Soybean Oil and Beef Tallow Alcoholysis by Acid Heterogeneous Catalysis, *Appl. Catal.*, A, 361, 42–48.
- Song, S.X. and Kydd, R.A., 1998, Activation of Sulfated Zirconia Catalysts Effect of Water Content on Their Activity in n-butane isomerization, *J. Chem. Soc. - Faraday Trans.*, 94, 1333–1338.
- Sturt, N.R.M., Vieira, S.S., dan, Moura, F.C.C., 2019, Catalytic Activity of Sulfated Niobium Oxide for Oleic Acid Esterification, *J. Environ. Chem. Eng.*, 7, 102-866.
- Suyin, G., Kiat, Ng.H., Hinn, C.P., Lim, L.F., 2012, Heterogeneous Free Fatty Acids Esterification in Waste Cooking Oil Using Ion Exchange Resins, *Fuel Process. Technol.*, 102, 67-72.
- Tenvuttirojna, C., Chuasomboon, N., Numpilai, T., Faungnawakij, K., Chareonpanich, M., Limtrakul, J., dan Witoon, T., 2019, Development of SO₄²⁻-ZrO₂ Acid Catalysts Admixed with a CuO-ZnO-ZrO₂ Catalyst for CO₂ Hydrogenation to Dimethyl Ether, *Fuel*, 241, 695–703.
- Tian, X., Xiao, T., Yang, C., Zhou, Z., dan Ke, H., 2010, Synthesis of Crystalline Ordered Mesoporous CaO-ZrO₂ Solid Solution as A Promising Solid Base, *Mater. Chem. Phys.*, 124, 744-747.
- Wang, Z., Sun, X., Sun, G., dan Liu, G., 2007, Preparation of Biodiesel Catalyzed by SO₄²⁻/Fe₂O₃ Solid Super Acid, *China Oils and Fats*, 32, 59-62.



Wijaya, K., Hadi, K., Herlina, I., and Kurnia, A.T., 2016, *Nanomaterial: Aplikasinya dalam Pembuatan Biofuel*, Gadjah Mada University Press, Yogyakarta.

Wijaya. K., Herlina, I., Trisunaryanti, W., Nuryono, dan Simbolon, S., 2018, Biodiesel Preparation from Oil Fraction of Crude Pond Palm Oil through ZrO₂/SO₃H⁺-Catalyzed Esterification Followed by KOH-Catalyzed Transesterification, *Asian J. Chem.*, 30, 724-730.

Xia, S., Guo, X., Mao, D., Shi, Z., Wu, G., dan Lu, G., 2014, Biodiesel Synthesis over CaO-ZrO₂ Solid Base Catalyst Prepared by Urea-Nitrate Combustion Method, *RSC Adv.*, 01, 1-8.

Yamaguchi, T., 1990, Recent Progress in Solid Superacid, *Appl. Catal.*, 61, 1-25.

Zhang, Q., Zhang, Y., Li, H., GaO, C., dan Zhao, Y., 2013, Heterogeneous CaO-ZrO₂ Acid-Base Bifunctional Catalysts for Vapor-Phase Selective Dehydration of 1,4-butanediol to 3-buten-1-ol, *J. Catal.*, 466, 233-239

Zhou, D., Qiao, B., Li, G., Xue, S., dan Yin, J., 2017, Continuous Production of Biodiesel from Microalgae by Extraction Coupling with Transesterification Under Supercritical Conditions, *Bioresour. Technol.*, 238, 609-615.