BAB V
KESIMPULAN & SARAN

5.1 Kesimpulan

Berdasarkan penelitian pirolisis LDPE menjadi bahan bakar cair, dapat disimpulkan bahwa:

1. Katalis yang menghasilkan produk pirolisis terbaik merupakan yang mempunyai situs asam Bronsted terbanyak, yaitu ZSM-5.
2. Temperatur yang menghasilkan produk pirolisis terbaik merupakan variasi temperatur 295 °C untuk katalis ZSM-5 dan temperatur 250 °C untuk katalis SiO_2.
3. Pengaruh keasamaan katalis meningkatkan perolehan produk cair dengan menggunakan katalis ZSM-5 dan SiO_2 pada temperatur 250 °C dan menurunkan perolehan produk cair pada temperatur 295 °C.

5.2 Saran

Saran untuk penelitian pirolisis LDPE menjadi bahan bakar cair adalah:

1. Perlu dilakukannya analisa NH_3-TPD untuk mengetahui pengaruh impregnasi katalis pada jumlah situs asam Bronsted dan Lewis.
2. Padatan hasil pirolisis dapat di pirolisis kembali sehingga menghasilkan produk cair yang lebih banyak. Namun perlu dipertimbangkan cara memisahkan katalis dari produk padat.
3. Pada penelitian selanjutnya, penggunaan pelarut dapat dilakukan dengan menggunakan hasil produk cair yang dihasilkan dari proses pirolisis sehingga penggunaan pelarut kerosene hanya digunakan saat sebelum ada produk cair.

DAFTAR PUSTAKA

Abbot, J. (1989). Role of Brønsted and Lewis acid sites during cracking reactions of alkanes. *Applied Catalysis*, *47*(1), 33–44. https://doi.org/10.1016/S0166-9834(00)83260-1

Abid, A., Pandebesie, E. S., Lingkungan, T., Teknik, F., Teknologi, I., Nopember, S., Arief, J., Hakim, R., & Indonesia, S. (2016). *Studi Pemrosesan Akhir Buangan Padat Dengan Teknologi Konversi Termal*. 1–6.

Adharsya, T. (2019). *Sebegini Parah Ternyata Masalah Sampah Plastik di Indonesia*. https://www.cnbcindonesia.com/lifestyle/20190721140139-33-86420/sebegini-parah-ternyata-masalah-sampah-plastik-di-indonesia

Almu, M. A., Syahrul, S., & Padang, Y. A. (2014). ANALISA NILAI KALOR DAN LAJU PEMBAKARAN PADA BRIKET CAMPURAN BIJI NYAMPLUNG (Calophyllm Inophyllum) DAN ABU SEKAM PADI. *Dinamika Teknik Mesin*, *4*(2), 117–122. https://doi.org/10.29303/d.v4i2.61

American Chemistry Council. (2016). *Plastic Packaging Resins Resin Codes Descriptions Properties Product Applications Products Made with Recycled Content**. 1–3. https://plastics.americanchemistry.com/Plastic-Resin-Codes-PDF/

American, O. F. T. H. E., & Society, C. (2001). *Chemistry in Context : Applying Chemistry to Society* (Vol. 6, Issue 2). papers3://publication/uuid/6F1F845E-6B18-4F04-A952-93497AAE1717

Anuar Sharuddin, S. D., Abnisa, F., Wan Daud, W. M. A., & Aroua, M. K. (2016). A review on pyrolysis of plastic wastes. *Energy Conversion and Management*, *115*, 308–326. https://doi.org/10.1016/j.enconman.2016.02.037

Arief, L. M. (2016). *Pengolahan Limbah Industri: Dasar-Dasar Pengetahuan dan Aplikasi di Tempat Kerja*. ANDI OFFSET. https://books.google.co.id/books?id=mFM5DgAAQBAJ&printsec=frontcover&dq=hirarki+pengolahan+limbah&hl=ban&sa=X&ved=0ahUKEwj-po2Zo_PnAhWNe30KHcq7DBkQ6AEILjAB#v=onepage&q=hirarki pengolahan limbah&f=false

Arvirianty, A. (CNBC I. (2019). *Nasib RI: Stok BBM 20 Hari, Cadangan Minyak Sisa 10 Tahun*. https://www.cnbcindonesia.com/news/20190116121717-4-50911/nasib-ri-stok-bbm-20-hari-cadangan-minyak-sisa-10-tahun

ASTM D445-06. (2008). Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity). *Manual on Hydrocarbon Analysis, 6th Edition*, 1–10.

ASTM International. (2009). Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (reapproved 2007). *ASTM Standard D240-02*, *i*(Reapproved), 1–9.

Bahng, M. K., Mukarakate, C., Robichaud, D. J., & Nimlos, M. R. (2009). Current technologies for analysis of biomass thermochemical processing: A review. *Analytica Chimica Acta*, *651*(2), 117–138. https://doi.org/10.1016/j.aca.2009.08.016

Basu, P. (2010). *Biomass Gasification and Pyrolysis Practical Design and Theory*. Elsevier Inc.

Batool, M., Shah, A. T., Din, M. I., & Li, B. (2012). Micelle directed synthesis of (C 19H 42N) 4H 3(PW 11O 39) nanoparticles and their catalytic efficiency for oxidative degradation of azo dye. *Journal of Sol-Gel Science and Technology*, *63*(1), 194–199. https://doi.org/10.1007/s10971-012-2779-6

Bhakti, H., & Sudarmanta, B. (2017). Studi Eksperimental Pengaruh Penambahan Sistem Ceratan pada Gasifikasi Biomassa Briket Municipal Solid Waste terhadap Performa Gasifier Tipe Downdraft. *Jurnal Teknik ITS*, *5*(2), 610–614. https://doi.org/10.12962/j23373539.v5i2.20188

Billmeyer, F. W. (1963). Textbook of Polymer Science. In *Kobunshi* (Vol. 12, Issue 3). https://doi.org/10.1295/kobunshi.12.240

Booma, M., Selke, S. E., & Giacin, J. R. (1994). Degradable Plastics. *Journal of Elastomers and Plastics*, *26*(2), 104–142. https://doi.org/10.1177/009524439402600203

Bramantoro, T. (2018). *Analisis Tingkat Daur Ulang Sampah 2018: Bagaimana Indonesia Melawan Polusi Sampah Plastik Artikel ini telah tayang di Tribunnews.com dengan judul Analisis Tingkat Daur Ulang Sampah 2018: Bagaimana Indonesia Melawan Polusi Sampah Plastik.*

Budsaereechai, S., Hunt, A. J., & Ngernyen, Y. (2019). Catalytic pyrolysis of plastic waste for the production of liquid fuels for engines. *RSC Advances*, *9*(10), 5844–5857. https://doi.org/10.1039/c8ra10058f

Crawford, R. J. (1998). *Plastics Engineering 3rd Edition*. 530.

Demirbas, A. (2004). Pyrolysis of municipal plastic wastes for recovery of gasoline-range hydrocarbons. *ournal of Analytical and Applied Pyrolysis*, *72*(1), 97–102. https://doi.org/10.1016/j.jaap.2004.03.001

Demirbaş, A., & Arin, G. (2002). An overview of biomass pyrolysis. *Energy Sources*, *24*(5), 471–482. https://doi.org/10.1080/00908310252889979

Elfadly, A. M., Zeid, I. F., Yehia, F. Z., Abouelela, M. M., & Rabie, A. M. (2017). Production of aromatic hydrocarbons from catalytic pyrolysis of lignin over acid-activated bentonite clay. *Fuel Processing Technology*

Encinar, J. M., González, J. F., Martínez, G., & Román, S. (2009). Catalytic pyrolysis of exhausted olive oil waste. *Journal of Analytical and Applied Pyrolysis*, *85*(1–2), 197–203. https://doi.org/10.1016/j.jaap.2008.11.018

Erdogan, S. (2020). Recycling of Waste Plastics into Pyrolytic Fuels and Their Use in IC Engines. *Sustainable Mobility*, *1*, 1–23. https://doi.org/10.5772/intechopen.90639

Fernandez, Y., Arenillas, A., & Angel, J. (2011). Microwave Heating Applied to Pyrolysis. *Advances in Induction and Microwave Heating of Mineral and Organic Materials*, *April 2018*. https://doi.org/10.5772/13548

Flieger, M., Kantorová, M., Prell, A., Řezanka, T., & Votruba, J. (2003). Biodegradable plastics from renewable sources. *Folia Microbiologica*, *48*(1), 27–44. https://doi.org/10.1007/BF02931273

Frendy, K., & Evan, N. R. (2019). *Pengolahan Limbah Ldpe Menjadi Bahan Bakar Cair*.

Galadima, A., & Muraza, O. (2015). In situ fast pyrolysis of biomass with zeolite catalysts for bioaromatics/gasoline production: A review. *Energy Conversion and Management*, *105*, 338–354. https://doi.org/10.1016/j.enconman.2015.07.078

Gao, F. (2010). *Pyrolysis of Waste Plastics into Fuels*.

Geyer, R., Jambeck, J. R., & Law, K. L. (2017). *Production, use, and fate of all plastics ever made*. https://advances.sciencemag.org/content/3/7/e1700782

Guerra, E. S. (2013). *Handbook Of Polymer Synthesis , Characterization, and Processing*.

Hernández, M. del R., Gómez, A., García, Á. N., Agulló, J., & Marcilla, A. (2007). Effect of the temperature in the nature and extension of the primary and secondary reactions in the thermal and HZSM-5 catalytic pyrolysis of HDPE. *Applied Catalysis A: General*, *317*(2), 183–194. https://doi.org/10.1016/j.apcata.2006.10.017

Inderscience Publishers. (2014). *Converting polyethylene waste into liquid fuel*. https://phys.org/news/2014-01-polyethylene-liquid-fuel.html

Klass, D. L. (1998). *Biomass for Renewable Energy, Fuels, and Chemicals* (1st ed.).Academic Press. https://books.google.co.id/books?hl=en&lr=&id=udDHC3Ss7DAC&oi=fnd&pg=PP1&dq=biomass+energy&ots=Q2eh3g6zns&sig=IL4U_AQabf_PUijUUMH4z8O-lP8&redir_esc=y#v=onepage&q=biomass energy&f=false

Liang, Y. W., Yu, C. L., Shen, G. Z., Sun, Q. R., Li, J. W., Yang, Y. C., She, H. Q., Zhang, B., & Tan, G. (2013). Geochemical characteristics of granites in the Suonaga Pb-Zn-Ag deposit of Dong Ujimqin Banner, Inner Mongolia, and their tectonic and ore-forming implications. In *Geology in China* (Vol. 40, Issue 3).

López, A., de Marco, I., Caballero, B. M., Laresgoiti, M. F., Adrados, A., & Aranzabal, A. (2011). Catalytic pyrolysis of plastic wastes with two different types of catalysts: ZSM-5 zeolite and Red Mud. *Applied Catalysis B: Environmental*, *104*(3–4), 211–219. https://doi.org/10.1016/j.apcatb.2011.03.030

Masoud, A. I., Tsay, T. P., BeGole, E., & Bedran-Russo, A. K. (2014). Force decay evaluation of thermoplastic and thermoset elastomeric chains: A mechanical design comparison. *Angle Orthodontist*, *84*(6), 1026–1033. https://doi.org/10.2319/010814-28.1

Miandad, R., Barakat, M. A., Aburiazaiza, A. S., Rehan, M., & Nizami, A. S. (2016) Catalytic pyrolysis of plastic waste: A review. *Process Safety and Environmental Protection*, *102*, 822–838. https://doi.org/10.1016/j.psep.2016.06.022

Nakabayashi, H. (1992). Properties of Acid Sites on TiO 2 –SiO 2 and TiO 2 –Al 2 O 3 Mixed Oxides Measured by Infrared Spectroscopy . In *Bulletin of the Chemical Society of Japan* (Vol. 65, Issue 3, pp. 914–916). https://doi.org/10.1246/bcsj.65.914

Onwudili, J. A., Insura, N., & Williams, P. T. (2009). Composition of products from the pyrolysis of polyethylene and polystyrene in a closed batch reactor: Effects of temperature and residence time. *Journal of Analytical and Applied Pyrolysis*. https://doi.org/10.1016/j.jaap.2009.07.008

Park, J. J., Park, K., Park, J. W., & Kim, D. C. (2002). Characteristics of LDPE pyrolysis. *Korean Journal of Chemical Engineering*, *19*(4), 658–662. https://doi.org/10.1007/BF02699313

Permana, E. (2019). *Indonesia hasilkan 67 juta ton sampah pada 2019*. https://www.aa.com.tr/id/headline-hari/indonesia-hasilkan-67-juta-ton-sampah-pada-2019/1373712

Perry, R. H., & Green, D. W. (1997). Perry's Engineers' Handbook. In *Perry's Engineers' Handbook*. http://pubs.acs.org/doi/pdf/10.1021/ed027p533.1

Pinto, F., Costa, P., Gulyurtlu, I., & Cabrita, I. (1999). Pyrolysis of plastic wastes. 1. Effect of plastic waste composition on product yield. *Journal of Analytical and Applied Pyrolysis*, *51*(1), 39–55. https://doi.org/10.1016/S0165-2370(99)00007-8

Plastindo, M. (2019). *Pabrik Biji Plastik LDPE Terbaik di Indonesia*. https://mutiaraplastindo.co.id/pabrik-biji-plastik-ldpe/

Puspita, S. (2018). *Indonesia Penyumbang Sampah Plastik Terbesar Kedua di Dunia*. https://megapolitan.kompas.com/read/2018/08/19/21151811/indonesia-penyumbang-sampah-plastik-terbesar-kedua-di-dunia

Ritchie, Hannah Roser, M. (2018). *Plastic Pollution*. https://ourworldindata.org/plastic-pollution

Shah, J., Jan, M. R., Mabood, F., & Jabeen, F. (2010). Catalytic pyrolysis of LDPE leads to valuable resource recovery and reduction of waste problems. *Energy Conversion and Management*, *51*(12), 2791–2801. https://doi.org/10.1016/j.enconman.2010.06.016

Shah, N., Rockwell, J., & Huffman, G. P. (1999). Conversion of waste plastic to oil: Direct liquefaction versus pyrolysis and hydroprocessing. *Energy and Fuels*, *13*(4), 832–838. https://doi.org/10.1021/ef9802431

Shamiri, A., & Chakrabarti, M. H. (2014). *The Influence of Ziegler-Natta and Metallocene Catalysts on Polyolefin Structure, Properties, and Processing Ability*. https://www.mdpi.com/1996-1944/7/7/5069/htm

Sriatun, Susanto, H., Widayat, & Darmawan, A. (2019). Characteristic of ZSM-5 catalyst supported by nickel and molybdenum. *IOP Conference Series: Materials Science and Engineering*, *509*(1). https://doi.org/10.1088/1757-899X/509/1/012138

Subramanian, P. M. (2000). Plastics recycling and waste management in the US. *Resources, Conservation and Recycling*, *28*(3–4), 253–263. https://doi.org/10.1016/S0921-3449(99)00049-X

Tüccar, G., Tosun, E., & Uludamar, E. (2018). Investigations of Effects of Density and Viscosity of Diesel and Biodiesel Fuels on NOx and other Emission Formations. *Academic Platform Journal of Engineering and Science*, *6*(2), 81–85. https://doi.org/10.21541/apjes.371015

Van de Velden, M., Baeyens, J., Brems, A., Janssens, B., & Dewil, R. (2010). Fundamentals, kinetics and endothermicity of the biomass pyrolysis reaction. *Renewable Energy*, *35*(1), 232–242. https://doi.org/10.1016/j.renene.2009.04.019

Waluyo, D. L. (2018). *Bioremediasi Limbah* (A. H. Riyanto (ed.); 1st ed.). Universitas Muhammadiah Malang. https://books.google.co.id/books?id=mgZ-DwAAQBAJ&pg=PA16&dq=jenis+jenis+limbah+berdasarkan+sumbernya&hl=ban&sa=X&ved=0ahUKEwiVrP7O6c_nAhX0yDgGHdngDKkQ6AEILTAB#v=onepage&q=jen is jenis limbah berdasarkan sumbernya&f=false

Watson, R. J., Botero, M. L., Ness, C. J., Morgan, N. M., & Kraft, M. (2013). An improved methodology for determining threshold sooting indices from smoke point lamps. *Fuel*, *111*, 120–130. https://doi.org/10.1016/j.fuel.2013.04.024

Wharton, A. (1991). *Diesel Engines 3rd ed* (3rd ed.). Stanfords Maritime. https://books.google.co.id/books?hl=en&lr=&id=kgj32v8VBaUC&oi=fnd&pg=PA1&dq=Diesel+Engine+3rd,+Aj.+Wharton&ots=uHomQj-HJ9&sig=k5wRZQW7o0wY3JWwWqAPVqvw2Nc&redir_esc=y#v=onepage&q=Diesel Engine 3rd%2C Aj. Wharton&f=false

Yang, Y., Boehman, A. L., & Santoro, R. J. (2007). A study of jet fuel sooting tendency using the threshold sooting index (TSI) model. *Combustion and Flame*, *149*(1–2), 191–205. https://doi.org/10.1016/j.combustflame.2006.11.007

Zhang, Z., Zhang, L., Liu, F., Sun, Y., Shao, Y., Sun, K., Zhang, S., Liu, Q., Hu, G., & Hu, X. (2020). Tailoring the surface properties of Ni/SiO2 catalyst with sulfuric acid for enhancing the catalytic efficiency for steam reforming of guaiacol. *Renewable Energy*, *156*, 423–439. https://doi.org/10.1016/j.renene.2020.04.