

BAB V

KESIMPULAN DAN SARAN

5.1. Kesimpulan

Kesimpulan yang dapat ditarik setelah melakukan penelitian mengenai pengolahan LDPE, HDPE, dan LLDPE adalah sebagai berikut:

1. Pirolisis dengan reaktor *batch* secara satu tahap tanpa katalis sulit untuk dilakukan.
2. Pirolisis dengan *residence time* yang rendah menyebabkan terbentuknya *wax*.

5.2. Saran

Saran yang dapat diberikan untuk penelitian berikutnya adalah sebagai berikut:

1. Perlu digunakan katalis untuk proses pirolisis, karena katalis dapat menurunkan temperatur *cracking*.
2. *Heating rate* reaktor *batch* harus dapat ditingkatkan.
3. *Sensor* temperatur reaktor harus dicek secara berkala.
4. Pemanas listrik dibuat lebih tahan panas, karena pemanas reaktor sering rusak (putus).
5. Melakukan penelitian lebih lanjut untuk jenis plastik LLDPE, karena penelitian LLDPE masih sangat sedikit.

DAFTAR PUSTAKA

1. *Plastic waste inputs from land into the ocean.* **Jambeck, Jenna R. and Roland Geyer, Chris Wilcox, Theodore R. Siegler, Miriam Perryman, Anthony Andrady, Ramani Narayan, Kara Lavender Law.** 6223, 2015, Vol. 347.
2. **Forrest, Martin J.** *Recycling of Polyethylene Terephthalate, 2nd Edition.* s.l. : Walter de Gruyter GmbH & Co KG, 2019.
3. **Enval Ltd.** Plastic Aluminium Laminates: A Challenge. [Online] Enval Ltd, 2018. [Cited: April 17, 2018.] Enval.com.
4. *Effect of Plastic Types on Pyrolysis Liquid Oil.* **Miandad, R and M.A. Barakat, Asad S. Aburiazza, M.Rehan, I.M.I. Ismail.** 2016, International Biodeterioration & Biodegradation.
5. *Pyrolysis Study of Polypropylene and Polyethylene in to Premium Oil Products .* **Ahmad, Imtiaz and M. Ismail Khan, Hizbullah Khan, M. Ishaq, Razia Tariq, Kashif Gul, Waqas Ahmad.** 2014, International Journal of Green Energy.
6. **Scheirs, John and Kaminsky, Walter.** *Feedstock Recycling and Pyrolysis of Waste Plastics: Converting Waste Plastics into Diesel and Other Fuels.* West Sussex : Wiley, 2006.
7. *Pyrolysis of plastic wastes. 1. Effect of plastic waste composition on product yield.* **Pinto, F and P. Costa, I. Gulyurtlu, I. Cabrita.** September 1998, Journal of Analytical and Applied Pyrolysis , Vol. 51, pp. 40-53.
8. *Pyrolysis Behavior of Different Type of Materials Contained in the Rejects of Packaging Waste Sorting Plant.* **Adrados, A. and De Marco, I., Lopez-Urionabarrenechea, A., Caballero, B. M., Laresgoiti, M. F.** September 2012, Waste Management, Vol. 33, p. 56.
9. *Recent advances in the gasification of waste plastics. A critical overview.* **Lopez, Gartzen and Maite Artetxe, Mairer Amutio, Jon Alvarez, Javier Bilbao, Martin Olazar.** 2018, Renewable and Sustainable Energy Reviews, Vol. 82, pp. 576-594.
10. *Pyrolysis of Tetrapack.* **Korkmaz, A. and Yanik, J., Brebu, M., & Vasile, C.** August 2009, Waste Management, Vol. 29, pp. 2836-2841.
11. **Rhyner, Charles R. and Leander J. Schwartz, Robert B. Wenger, Mary G. Kohrell.** *Waste Management and Resource Recovery.* Boca Raton : CRC Press, 2017.
12. **White, P.R and M. Franke, P. Hindle.** *Integrated Solid Waste Management: A Lifecycle Inventory.* Gaithersburg : Aspen Publisher Inc, 1995.
13. *Removal and Recovery of Metals by Biosorbents and Biochars Derived From Biowastes.* **Niazi, N.K. and B.Murtaza, I.Bibi, M.Shahid, J.C.White , M.F.Nawaz, S.Bashir, M.B.Shakoor, G.Choppala, G.Murtaza, H.Wang.** 2016, Environmental Materials and Waste : Resource Recovery and Pollution Prevention.

14. **Kaza and Silpa, Lisa Yao, Perinaz Bhada-Tata, Frank Van Woerden.** *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050.* Washington, DC : World Bank, 2018.
15. **Hoorweg, Daniel and Perinaz Bhada-Tata.** *WHAT A WASTE A Global Review of Solid Waste Management.* World Bank. Washington D.C : s.n., 2012.
16. **Patni, N. and P. Shah, S. Agarwal, P. Singhal.** *Alternate Strategies for Conversion of Waste Plastic to Fuels.* s.l. : ISRN Renewable Energy, 2013.
17. **Bhatt, J.R.** *PLASTICS IN LIFE AND ENVIRONMENT.* Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India., New Delhi : s.n., 2018.
18. **Salaudeen, S.A. and P.Arku, Animesh Dutta.** Gasification of Plastic Solid Waste and Competitive Technologies. [book auth.] Sultan As Salam. *Plastics to Energy: Fuel, Chemicals, and Sustainability Implications.* Canada : William Andrew, 2019, p. 280.
19. **Crawford, R.J.** *Plastic Engineering 3rd Edition.* Oxford : Butterworth-Heinemann, 1993.
20. **Rosato, Dominick V. and Donald V Rosato, Matthew v Rosato.** *Plastic Product Material and Selection Handbook.* Oxford : Elsevier, 2004.
21. **Patrick, Stuart.** *Practical Guide to Polyvinyl Chloride.* Shropshire : iSmithers Rapra Publishing, 2005.
22. **Rochmadi and Permono, Ajar.** *Mengenal Polimer dan Polimerasisasi.* Yogyakarta : UGM Press, 2018.
23. **Sari, Nasmi Herlina.** *Material Teknik.* Yogyakarta : Deepublish, 2018.
24. **Maier, Clive and Calafut, Theresa.** *Polypropylene: The Definitive User's Guide and Databook.* New York : William Andrew, 1998.
25. **Harper, Charles.** *Handbook of Plastics, Elastomers and Composites.* s.l. : McGraw-Hill Professional, 2002.
26. **Leach, Robert.** *The Printing Ink Manual.* Padstow : Springer Science and Bussiness, 2012.
27. **Mandal, Suranjana and Dey, Ayan.** PET Chemistry. [book auth.] Thomas Sabu and Krishnan Kanny, Abitha VK, Martin George Thomas Ajay Vasudeo Rane. *Recycling of Polyethylene Terephthalate Bottles.* s.l. : William Andrew, 2018, p. 3.
28. **Morris, Barry A.** *The Science and Technology of Flexible Packaging: Multilayer Films from Resin and Process to End Use.* Oxford : William Andrew, 2016.
29. *Food Packaging – Roles, Materials, and Environmental Issues.* **Marsh, K. and B, Bugusu.** 2007, Journal of Food Science, pp. R39-R-55.

30. **Richardson, Terry L. and Lokensgard, Erik.** *Industrial Plastics: Theory and Applications*. s.l. : Cengage Learning, 2004.
31. **Rajaram, Vasudevan and Faisal Zia Siddiqui, Sanjeev Agrawal, Mohammad Emran Khan.** *SOLID AND LIQUID WASTE MANAGEMENT WASTE TO WEALTH: SOLID AND LIQUID WASTE MANAGEMENT WASTE TO WEALTH*. Delhi : PHI Learning Pvt. Ltd., 2016.
32. *Toxic Pollutants from Plastic Waste- A Review*. **Rinku, Verma and K.S.Vinoda, M.Papireddy, A.N.S.Gowda.** Procedia Environmental Science, Bangalore : Elsevier, 2016, Vol. 35.
33. *Dioxin Reassessment: Draft Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD) and Related Compounds*. **Agency, U.S Environmental Protection.** 2003.
34. **Ciuta, Simona and Demetra Tsiamis, Marco J. Castaldi.** *Gasification of Waste Materials: Technologies for Generating Energy, Gas, and Chemicals from Municipal Solid Waste, Biomass, Nonrecycled Plastics, Sludges, and Wet Solid Wastes*. London : Academic Press, 2017.
35. **Ocean, Conservancy.** *Stemming the Tide : Land-based Strategies for a Plastic Free Ocean*. s.l. : McKinsey Center for Conservancy Ocean, 2015.
36. **Aguado, Jose and Serrano, David P.** *Feedstock Recycling of Plastic Wastes*. Cambridge : Royal Society of Chemistry, 2007.
37. **Niaounakis, Michael.** *Management of Marine Plastic Debris*. Oxford : William Andrew, 2017.
38. *A review on pyrolysis of plastic wastes*. **Sharuddin, Shafferina Dayana Anuar and Faisal Abnisa, Wan Mohd Ashri Wan Daud, Mohamed Kheireddine Aroua.** 2016, Energy Convention and Management, p. 317.
39. **Gao, Feng.** *Pyrolysis of Waste Plastics into Fuels*. University of Caterbury. 2010. Thesis.
40. *Fluidized bed thermal degradation products of HDPE in an inert atmosphere and in air–nitrogen mixtures*. **Mastral, F.J. and E. Esperanza, C.Berrueco, M.Juste, J.Ceamanos.** 1, October 2003, Journal of Analytical and Applied Pyrolysis, Vol. 70, pp. 1-17.
41. *Ind. Eng. Chem. Res.* . **R.W.J. Westerhout, J. Waanders, J.A.M. Kuipers, W.P.M. van Swaij,** 37, 1998.
42. *Wax Formation in the Pyrolysis of Polyolefins in a Conical Spouted Bed Reactor*. *Energy and Fuel*. **Aguado, Roberto and Marti´n Olazar, Mari´a J. San Jose´, Beatriz Gaisa´n, Javier Bilba.** 16, 2002.
43. *Kinetic Evaluation of the Pyrolysis of Polyethylene Waste*. *Energy and Fuel*. **Costa, Paula A. and Bernardo, Filomena J. PintoAna. M. RamosIbrahim K. GulyurtluIsabel A. CabritaMaria. S.** 21, 2007.

44. *Characteristics of LDPE Pyrolysis. Korean Journal Chemical Engineering.* **Jong Jin, Park and Kwinam Park, Jin-Won Park and Dong Chan Kim.** 19, Seoul : s.n., 2002.
45. *The pyrolysis of individual plastics and plastic mixture in a fixed bed reactor.* **Williams, E.A., Williams, P.T.,** s.l. : J. Chem. Tech. Biotech, 1997, Journal of Chemical Technology & Biotechnology 70, pp. 9-20.
46. *Study of the polymer-catalyst contact effectivity and the heating rate influence on the HDPE pyrolysis.* **A. Marcilla, M.R. Hernandez, A.N. Garcia.** 79, s.l. : J. Anal. Appl. Pyrolysis , 2007.
47. *Ash and Fire, Char and Biochar in the Enviroment. Land Degradation and Development .* **Kuzyakov, Yakiv & Agustin Merino.** 29, 2018.
48. *Combustion of char from plastic wastes pyrolysis.* **Saptoadi, H., Rohmat, T. A., & Sutoyo.** 2016.
49. *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.* **Onwudili, J. A., Insura, N., & Williams, P. T.** 86, 2009, Vol. 2.
50. **Utomo, Sriviana.** *KAJIAN AWAL PIROLISIS PET DAN HDPE SEBAGAI LANGKAH AWAL STUDI PENGOLAHAN LIMBAH PLASTIK-ALUMINIUM (POLILAMINAT).* Bandung : Universitas Katolik Parahyangan, 2019.
51. *Thermolysis of polyethylene. Polymer Degradation and Stability.* **McCaffrey, W. C., Kamal, M. R., & Cooper, D. G.** 47, 1995, Vol. 1.
52. *Menghasilkan Biodiesel Murah: Mengatasi Polusi & Kelangkaan BBM.* **Prihandana, Rama, Roy Hendroko dan Makmuri Nuramin.** 2006.
53. **Petroleum, Bharat.** Petroleum. <http://www.petroleum.co.uk/api>. [Online] 2015. [Cited: April 3, 2020.] <http://www.petroleum.co.uk/api>.
54. **ToolBox, Engineering.** Engineering Toolbox. [Online] 2017. [Cited: April 16, 2020.] https://www.engineeringtoolbox.com/hydrocarbon-boiling-melting-flash-autoignition-point-density-gravity-molweight-d_1966.html.
55. *Standard Test for Ash From Petroleum Product, D482.* **Ahmed, Y. A., .** Zahko : University of Zakho, 2015.
56. *Viscosity In: ChemPRIME.* **VitzeD.** California : Chemical Education Digital Library., 2019.
57. *A Laboratory Study to Determine Physical Characteristics of Heavy Oil After CO2 Saturation.* **Miller, J. S. & Jones, R. A.** Oklahoma : s.n., 1981.
58. **Standard, An American National.** *Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter.* 2007. Designation: D 240 – 02.

59. **International, ASTM.** *Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.* 2005. D 1298 – 99
60. —. *Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity).* 2000. D 445 – 06.
61. **Sharana, Shiva & Sheetal Kest.** (2019). *Physical and Chemical Characterization of Low Density Polyethylene and High Density Polyethylene.* Department of Studies in Biotechnology and Microbiology, Karnatak University Dharwad, Karnataka, India.
62. **Dilfi, Anna K.F.** (2011). *Linear Low Density Polyethylene.* Department of Polymer Science and Rubber Technology Cochin University of Science and Technology Kochi- 682 022, Kerala, India.
63. **Madhu, Gaurav.** (2014). *Mechanical and morphological properties of high density polyethylene and polylactide blends.* Department of Chemical Engineering, Thapar University, Patiala-147 004, Punjab, India. *J Polym Eng* 2014; 34(9): 813–821.
64. —. *Standard Test Method for Ash from Petroleum Products.* : D 482 – 03.
65. **Statistik, Badan Pusat.** *Statistik Lingkungan Hidup Indonesia : Pengelolaan Sampah di Indonesia.* Jakarta : Badan Pusat Statistik, 2018.
66. **Tripathi, Devesh.** *Practical Guide to Polypropylene.* Shropshire : iSmithers Rapra Publishing, 2002.
67. *Dioxin Reassessment: Draft Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD) and Related Compounds.* **Agency, U.S. Environmental Protection.** Health Assessment of 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD) and Related Compounds, Washington DC : s.n., 2003.
68. **Leach, Robert.** *The Printing Ink Manual.* Padstow : Springer Science and Bussiness, 2012.
69. *Polyethylene characterization by FTIR.* **J. V. Gulmine, P. R. Janissek, H. M. Heise, L. Akcelrud.** 2002, *Polymer Testing*, Vol. 21, pp. 557-563.
70. **Mieth, Anja and Eddo Hoekstra, Catherine Simoneau.** *Guidance for the identification of polymers in multilayer films used in food contact materials.* s.l. : European Union, 2016.
71. **International, ASTM.**