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DAFTAR PUSTAKA

Airbus A350 XWB Extra-Wide-Bodied Aircraft, Airbus., 2023, https://www.aerospace-technology.com/projects/a350wxb/ (diakses 16 Mei 2023).

Biodegradable plastics demand worldwide 2023., 2023, *Statista*, https://www.statista.com/statistics/1130192/global-biodegradable-plastics-demand/ (diakses 5 Juni 2023).

Global bioplastic production capacity shares by material., 2023, *Statista*, https://www.statista.com/statistics/1283701/global-bioplastic-production-capacity-shares-by-material/ (diakses 5 Juni 2023).

Global propylene demand & capacity 2015-2022., 2023, *Statista*, https://www.statista.com/statistics/1246689/propylene-demand-capacity-forecast-worldwide/ (diakses 24 Maret 2023).

Agüero, A., Morcillo, M.D.C., Quiles-Carrillo, L., Balart, R., Boronat, T., Lascano, D., Torres-Giner, S., *dkk.*, 2019, *Study of the Influence of the Reprocessing Cycles on the Final Properties of Polylactide Pieces Obtained by Injection Molding*, *Polymers*, **11**(12), 1908, doi: 10.3390/polym11121908.

Ahmad, N.D., Kusmono, Wildan, M.W., dan Herianto., 2023, *Preparation and properties of cellulose nanocrystals-reinforced Poly (lactic acid) composite filaments for 3D printing applications*, *Results in Engineering*, **17**, 100842, doi: 10.1016/j.rineng.2022.100842.

Airbus., 2017, *Composites: Airbus continues to shape the future | Airbus*, https://www.airbus.com/en/newsroom/news/2017-08-composites-airbus-continues-to-shape-the-future (diakses 14 November 2022).

Al-Itry, R., Lamnawar, K. dan Maazouz, A., 2012, *Improvement of thermal stability, rheological and mechanical properties of PLA, PBAT and their blends by reactive extrusion with functionalized epoxy*, *3rd International Conference on Biodegradable and Biobased Polymers (BIOPOL-2011) - Strasbourg 2011*, **97**(10), 1898–1914, doi: 10.1016/j.polymdegradstab.2012.06.028.

Alsabri, A., Tahir, F. dan Al-Ghamdi, S.G., 2022, *Environmental impacts of polypropylene (PP) production and prospects of its recycling in the GCC region*, *Materials Today: Proceedings*, **56**, 2245–2251, doi: 10.1016/j.matpr.2021.11.574.

Anshari, R., Tsuboi, M., Sato, H., Tashiro, K. dan Ozaki, Y., 2025, *Raman and ATR-FTIR unmask crystallinity changes and carboxylate group and vinyl group accumulation in natural weathering polypropylene microplastics*, *Scientific Reports*, **15**(1), 2518, doi: 10.1038/s41598-025-85837-y.

Ardianto, H., Jamasri, J., Harnany, D. dan Muflikhun, M.A., 2026, *Comprehensive material, thermal, and physical characterization of multistage recycling of PP/PLA polymers for sustainable composite matrix development*, *Journal of Polymer Research*, **33**(4), 127, doi: 10.1007/s10965-026-04852-3.

Ariturk, G., Bilge, K., Seven, S.A. dan Menceloglu, Y.Z., 2024, *Morphological adaptation of expanded vermiculite in polylactic acid and polypropylene matrices for superior thermoplastic composites*, *Polymer Composites*, **45**(6), 5043–5050, doi: 10.1002/pc.28108.

Arthurs, B., Bull, D.J., Arumugam, V., Chambers, A.R. dan Santulli, C., 2015, *Porosity Effect on Residual Flexural Strength following Low Energy Impact of Carbon*

Pengembangan Matriks Campuran Polypropylene dan Polylactic Acid melalui Pemrosesan Ulang yang
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Fibre Composites, Polymers and Polymer Composites, SAGE Publications Ltd STM, **23**(4), 205–212, doi: 10.1177/096739111502300401.

Askadskii, A., Popova, M., Matseevich, T. dan Afanasyev, E., 2014, *The influence of the degree of crystallinity on the elasticity modulus of polymers*, Vol. 864–867, dipresentasikan pada Advanced Materials Research, hlm. 640–643, doi: 10.4028/www.scientific.net/AMR.864-867.640.

Assler, H. dan Telgkamp, J., 2006, *Design of Aircraft Structures under Special Consideration of NDT*.

Badia, J.D., Strömberg, E., Karlsson, S. dan Ribes-Greus, A., 2012, *The role of crystalline, mobile amorphous and rigid amorphous fractions in the performance of recycled poly (ethylene terephthalate) (PET)*, *Polymer Degradation and Stability*, **97**(1), 98–107, doi: 10.1016/j.polymdegradstab.2011.10.008.

Bai, Z. dan Dou, Q., 2018, *Rheology, Morphology, Crystallization Behaviors, Mechanical and Thermal Properties of Poly(lactic acid)/Polypropylene/Maleic Anhydride-Grafted Polypropylene Blends*, *Journal of Polymers and the Environment*, **26**(3), 959–969, doi: 10.1007/s10924-017-1006-5.

Balasubramanian, M., Saravanan, R. dan T, Sathish., 2025, *Optimization of processing parameters for enhanced tensile performance of 3D-printed TCNP reinforced PLA composites*, *Results in Engineering*, **26**, 104562, doi: 10.1016/j.rineng.2025.104562.

Barroeta Robles, J., Dubé, M., Hubert, P. dan Yousefpour, A., 2022, *Repair of thermoplastic composites: an overview*, *Advanced Manufacturing: Polymer & Composites Science*, **8**(2), 68–96, doi: 10.1080/20550340.2022.2057137.

Barros, J.J.P., Boskamp, L., Silva, I.D.S., Jaques, N.G., Barreto, J.V.M., Haag, K., Koschek, K., *dkk.*, 2023, *Biodegradation and thermal-oxidative degradation of propanediol based poly (lactic acid) oligomers*, *Journal of Polymer Research*, **30**(6), 227, doi: 10.1007/s10965-023-03609-6.

Beltrán, F.R., Infante, C., de la Orden, M.U. dan Martínez Urreaga, J., 2019, *Mechanical recycling of poly(lactic acid): Evaluation of a chain extender and a peroxide as additives for upgrading the recycled plastic.*, *Journal of Cleaner Production*, **219**, 46–56, doi: 10.1016/j.jclepro.2019.01.206.

Beniwal, P., Guliani, D. dan Toor, A.P., 2024, *Influence of functionalised lignin on strength and antioxidant properties of polylactic acid films*, *Journal of Polymer Research*, **31**(3), 68, doi: 10.1007/s10965-024-03912-w.

Bijarimi, M., Ahmad, S. dan Rasid, R., 2012, *Mechanical, Thermal and Morphological Properties of PLA/PP Melt Blends*.

Caballero, M.P., Chemello, E., Grande, A.M., Santana, M.H., Verdejo, R. dan López-Manchado, M.Á., 2022, *THERMOPLASTIC COATING ON CARBON FIBER FOR THE DESIGN OF SUSTAINABLE COMPOSITE MATERIALS*, Vol. 1, dipresentasikan pada ECCM 2022 - Proceedings of the 20th European Conference on Composite Materials: Composites Meet Sustainability, hlm. 1565–1570.

Callister, W.D., 2019, *Materials Science and Engineering*, Wiley, New York.

Chau, C.C., Williams, J.A., Solovyov, S.E., Powers, T.H. dan Koch, P.E., 2012, *The structure and properties of PLA/PP porous film*, Vol. 1, dipresentasikan pada Annual Technical Conference - ANTEC, Conference Proceedings, hlm. 255–259.

Codou, A., Anstey, A., Misra, M. dan Mohanty, A.K., 2018, *Novel compatibilized nylon-based ternary blends with polypropylene and poly(lactic acid):*

UNIVERSITAS GADJAH MADA
Pengembangan Matriks Campuran Polypropylene dan Polylactic Acid melalui Pemrosesan Ulang yang Dilelehkan Menggunakan Hot Air Convection dan Aplikasinya pada Self-Healing Komposit Serat Karbon
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morphology evolution and rheological behaviour', *RSC Advances*, **8**(28), 15709–15724, doi: 10.1039/C8RA01707G.

Dasari, A., Rohrmann, J. dan Misra, R.D.K., 2003a, *Microstructural aspects of surface deformation processes and fracture of tensile strained high isotactic polypropylene*, *Materials Science and Engineering: A*, **358**(1–2), 372–383, doi: 10.1016/S0921-5093(03)00331-9.

Dasari, A., Rohrmann, J. dan Misra, R.D.K., 2003b, *Surface microstructural modification and fracture behavior of tensile deformed polypropylene with different percentage crystallinity*, *Materials Science and Engineering: A*, **360**(1–2), 237–248, doi: 10.1016/S0921-5093(03)00405-2.

Debnath, M., Chakraborty, P. dan Surya Rao, G., 2025, *Effect of recycling and bio-filler addition on the mechanical, thermal, and morphological behavior of the injection molded flax/PLA green composite*, *Polymer Composites*, John Wiley & Sons, Ltd, **46**(6), 5358–5369, doi: 10.1002/pc.29296.

Drass, M., Muth, J., Louter, C. dan Schneider, J., 2019, *Stress whitening effects in transparent structural silicone adhesives*, *Glass Structures and Engineering*, **4**(3), 433–448, doi: 10.1007/s40940-019-00102-9.

Du, X., Pan, G., Qu, J. dan Zhao, X., 2013, *Experimental study on infrared extinction ability of foams cloud*, *Hongwai yu Jiguang Gongcheng/Infrared and Laser Engineering*, **42**(SUPPL.2), 412–415.

Elsawy, M.A., Kim, K.-H., Park, J.-W. dan Deep, A., 2017, *Hydrolytic degradation of polylactic acid (PLA) and its composites*, *Renewable and Sustainable Energy Reviews*, **79**, 1346–1352, doi: 10.1016/j.rser.2017.05.143.

Esmizadeh, E., Tzoganakis, C. dan Mekonnen, T.H., 2020, *Degradation Behavior of Polypropylene during Reprocessing and Its Biocomposites: Thermal and Oxidative Degradation Kinetics*, *Polymers*, **12**(8), 1627, doi: 10.3390/polym12081627.

Farah, S., Anderson, D.G. dan Langer, R., 2016, *Physical and mechanical properties of PLA, and their functions in widespread applications — A comprehensive review*, *Advanced Drug Delivery Reviews*, **107**, 367–392, doi: 10.1016/j.addr.2016.06.012.

Farahani, M.F., Bagheri, R. dan Marouf, B.T., 2024, *Investigation on the onset and progress of stress whitening in polypropylene using digital image processing*, *Polymer Bulletin*, **81**(8), 7139–7156, doi: 10.1007/s00289-023-05045-4.

Fernández, A., Santangelo-Muro, M., Fernández-Blázquez, J.P., Lopes, C.S. dan Molina-Aldareguia, J.M., 2021, *Processing and properties of long recycled-carbon-fibre reinforced polypropylene*, *Composites Part B: Engineering*, **211**, 108653, doi: 10.1016/j.compositesb.2021.108653.

Finnerty, J., Rowe, S., Howard, T., Connolly, S., Doran, C., Devine, D.M., Gately, N.M., *dkk.*, 2023, *Effect of Mechanical Recycling on the Mechanical Properties of PLA-Based Natural Fiber-Reinforced Composites*, *Journal of Composites Science*, **7**(4), 141, doi: 10.3390/jcs7040141.

Fortelny, I., Ujcic, A., Fambri, L. dan Slouf, M., 2019, *Phase Structure, Compatibility, and Toughness of PLA/PCL Blends: A Review*, *Frontiers in Materials*, **Volume 6-2019**, doi: 10.3389/fmats.2019.00206.

Galve, J.E., Elduque, D., Pina, C. dan Javierre, C., 2022, *Life Cycle Assessment of a Plastic Part Injected with Recycled Polypropylene: A Comparison with Alternative Virgin Materials*, *International Journal of Precision Engineering and Manufacturing-Green Technology*, **9**(3), 919–932, doi: 10.1007/s40684-021-00363-2.

Pengembangan Matriks Campuran Polypropylene dan Polylactic Acid melalui Pemrosesan Ulang yang
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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Gaxiola-Cuéllar, R., Martínez-Romero, O., Elías-Zúñiga, A., Olvera-Trejo, D., Reséndiz-Hernández, J. dan Soria-Hernández, C., 2020, *Investigation of the Mechanical Properties of Parts Fabricated with Ultrasonic Micro Injection Molding Process Using Polypropylene Recycled Material*, *Polymers*, **12**(9), 2033, doi: 10.3390/polym12092033.

Gibson, R.F., 2016, *Principles Of Composite Material Mechanics*, 4 ed., CRC Press Taylor & Francis Group.

Goh, G.D., Dikshit, V., Nagalingam, A.P., Goh, G.L., Agarwala, S., Sing, S.L., Wei, J., *dkk.*, 2018, *Characterization of mechanical properties and fracture mode of additively manufactured carbon fiber and glass fiber reinforced thermoplastics*, *Materials and Design*.

González-González, V.A., Neira-Velázquez, G. dan Angulo-Sánchez, J.L., 1998, *Polypropylene chain scissions and molecular weight changes in multiple extrusion*, *Polymer Degradation and Stability*, **60**(1), 33–42, doi: 10.1016/S0141-3910(96)00233-9.

Hamad, K., Kaseem, M. dan Deri, F., 2011, *Rheological and mechanical characterization of poly(lactic acid)/polypropylene polymer blends*, *Journal of Polymer Research*, **18**(6), 1799–1806, doi: 10.1007/s10965-011-9586-6.

Hao, T., Xu, D., Ming, Y., Zhang, S., Wei, Y., Zhou, Z., Nie, Y., *dkk.*, 2020, *Correlation between molecular weight and confined crystallization behavior of polymers grafted onto a zero-dimensional filler*, *CrystEngComm*, **22**(10), 1779–1788, doi: 10.1039/c9ce01606f.

Hao, X., Kaschta, J. dan Schubert, D.W., 2016, *Viscous and elastic properties of polylactide melts filled with silica particles: Effect of particle size and concentration*, *Composites Part B: Engineering*, **89**, 44–53, doi: 10.1016/j.compositesb.2015.11.030.

Hosseini, A., 2024, *Theoretical Assessment of the Environmental Impact of the Preheating Stage in Thermoplastic Composite Processing: A Step toward Sustainable Manufacturing*, *Journal of Manufacturing and Materials Processing*, **8**(3), 120, doi: 10.3390/jmmp8030120.

Hu, J. dan Wang, G., 2024, *Ductile polylactic acid/poly(butylene diglycolate): structures and properties*, *Polymer Bulletin*, **81**(11), 10175–10185, doi: 10.1007/s00289-024-05213-0.

Huang, J., Li, C. dan Liu, W., 2020, *Investigation of internal friction and fracture fatigue entropy of CFRP laminates with various stacking sequences subjected to fatigue loading*, *Thin-Walled Structures*, **155**, 106978, doi: 10.1016/j.tws.2020.106978.

Huang, Y., Gan, Y., Luan, Y., Cai, H., Liang, L. dan Ren, X., 2025, *Self-healing study of impact damage in carbon fiber/epoxy composites based on hybrid polyamide nanofibers*, *Polymer Composites*, John Wiley & Sons, Ltd, **46**(6), 5281–5294, doi: 10.1002/pc.29291.

Hwang, Y.-T., Kang, S.-Y., Kim, D.-H. dan Kim, H.-S., 2019, *The influence of consolidation temperature on in-plane and interlaminar mechanical properties of self-reinforced polypropylene composite*, *Composite Structures*, **210**, 767–777, doi: 10.1016/j.compstruct.2018.11.098.

Ike, P.O., Folley, D.E., Agwu, K.K., Chithambo, M.L., Chikwembani, S. dan Ezema, F.I., 2021, *Influence of dysprosium doping on the structural, thermoluminescence and optical properties of lithium aluminium borate*, *Journal of Luminescence*, **233**, 117932, doi: 10.1016/j.jlumin.2021.117932.

Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Islam, F., Donough, M.J., Gronhelme, E., Phillips, A.W., St John, N.A. dan Prusty, B.G., 2023, *Modelling the effect of hot gas torch heating on adjacent tows during automated fibre placement consolidation of thermoplastic composites*, *Journal of Thermoplastic Composite Materials*, **36**(10), 4211–4236, doi: 10.1177/08927057221123477.

Jansson, A., Möller, K. dan Gevert, T., 2003, *Degradation of post-consumer polypropylene materials exposed to simulated recycling—mechanical properties*, *Polymer Degradation and Stability*, **82**(1), 37–46, doi: 10.1016/S0141-3910(03)00160-5.

Javanshour, F., Prapavesis, A., Pournoori, N., Soares, G.C., Orell, O., Pärnänen, T., Kanerva, M., *dkk.*, 2022, *Impact and fatigue tolerant natural fibre reinforced thermoplastic composites by using non-dry fibres*, *Composites Part A: Applied Science and Manufacturing*, **161**, 107110, doi: 10.1016/j.compositesa.2022.107110.

Jiménez-Suárez, A., Buendía Sánchez, G. dan Prolongo, S.G., 2024, *Temperature-dependent synergistic self-healing in thermoplastic-thermoset blends: Unraveling the role of thermoplastics and dynamic covalent networks*, *Journal of Materials Research and Technology*, **29**, 550–557, doi: 10.1016/j.jmrt.2024.01.089.

Jud, K., Kausch, H.H. dan Williams, J.G., 1981, *Fracture mechanics studies of crack healing and welding of polymers*, *Journal of Materials Science*, **16**(1), 204–210, doi: 10.1007/BF00552073.

Jun, B.J.H. dan Juwono, A.L., 2011, *STUDI PERBANDINGAN SIFAT MEKANIK POLYPROPYLENE MURNI DAN DAUR ULANG*, *MAKARA of Science Series*, **14**(1), doi: 10.7454/mss.v14i1.461.

Kakakasery, J., Arumugam, V., Abdul Rauf, K., Bull, D., Chambers, A.R., Scarponi, C. dan Santulli, C., 2015, *Cure cycle effect on impact resistance under elevated temperatures in carbon prepreg laminates investigated using acoustic emission*, *Composites Part B: Engineering*, **75**, 298–306, doi: 10.1016/j.compositesb.2015.02.002.

Kang, H., Lu, X. dan Xu, Y., 2015, *Properties of immiscible and ethylene-butyl acrylate-glycidyl methacrylate terpolymer compatibilized poly (lactic acid) and polypropylene blends*, *Polymer Testing*, **43**, 173–181, doi: 10.1016/j.polymertesting.2015.03.012.

Karger-Kocsis, J. dan Bárány, T. (Ed.)., 2019, *Polypropylene Handbook: Morphology, Blends and Composites*, Springer International Publishing, Cham, doi: 10.1007/978-3-030-12903-3.

Kopinke, F.-D., Remmler, M., Mackenzie, K., Möder, M. dan Wachsen, O., 1996, *Thermal decomposition of biodegradable polyesters—II. Poly(lactic acid)*, *Polymer Degradation and Stability*, **53**(3), 329–342, doi: 10.1016/0141-3910(96)00102-4.

Kukurudziak, M., 2025, *Surface Defect Formation on Substrates in Silicon Technology*, Vol. 79, dipresentasikan pada Advances in Transdisciplinary Engineering, hlm. 379–386, doi: 10.3233/ATDE251004.

Kumar Pittala, R., Dhanaraju, G., Satish Ben, B. dan Avinash Ben, B., 2022, *Self-healing of matrix cracking and delamination damage assessment in microcapsules reinforced carbon fibre epoxy composite under flexural loading*, *Composite Structures*, **291**, 115691, doi: 10.1016/j.compstruct.2022.115691.

Kusmono, Mohd Ishak, Z.A., Chow, W.S., Takeichi, T., dan Rochmadi., 2008, *Compatibilizing effect of SEBS-g-MA on the mechanical properties of different*

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types of OMMT filled polyamide 6/polypropylene nanocomposites, *Composites Part A: Applied Science and Manufacturing*, **39**(12), 1802–1814, doi: 10.1016/j.compositesa.2008.08.009.

Lanzotti, A., 2023, *A comparison between mechanical properties of specimens 3D printed with virgin and recycled PLA*.

Lee, J.S. dan Kim, J.W., 2017, *Effect of cooling rate on mechanical properties of carbon fibre fabric and polypropylene composites*, *Materials Research Express*, IOP Publishing, **4**(9), 095304, doi: 10.1088/2053-1591/aa8927.

Li, M., Li, S., Liu, B., Jiang, T., Zhang, D., Cao, L., He, L., *dkk.*, 2021, *Rheological behavior, crystallization properties, and foaming performance of chain-extended poly (lactic acid) by functionalized epoxy*, *RSC Advances*, **11**(52), 32799–32809, doi: 10.1039/D1RA06382K.

Loganathan, S., babu, V.R., Mishra, R.K. dan Pugazhenthi, G., 2017, *Thermogravimetry Analysis for Characterization of Nanomaterials*, *Thermal and Rheological Measurement Techniques for Nanomaterials Characterization*, Elsevier, hlm. iv, doi: 10.1016/B978-0-323-46139-9.12001-8.

Lu, J., Sun, C., Yang, K., Wang, K., Jiang, Y., Tusiime, R., Yang, Y., *dkk.*, 2019, *Properties of Polylactic Acid Reinforced by Hydroxyapatite Modified Nanocellulose*, *Polymers*, **11**(6), 1009, doi: 10.3390/polym11061009.

Lv, S., Zhang, Y. dan Tan, H., 2019, *Thermal and thermo-oxidative degradation kinetics and characteristics of poly (lactic acid) and its composites*, *Waste Management*, **87**, 335–344, doi: 10.1016/j.wasman.2019.02.027.

Mae, H., Omiya, M. dan Kishimoto, K., 2008, *Material ductility and toughening mechanism of polypropylene blended with bimodal distributed particle size of styrene-ethylene-butadiene-styrene triblock copolymer at high strain rate*, *Journal of Applied Polymer Science*, **110**(6), 3941–3953, doi: 10.1002/app.28959.

Maia, B.S., Sain, M. dan Tjong, J., 2022, *Surface free energy study of virgin and recycled carbon fiber reinforced thermoplastic composites*, *Journal of Polymer Research*, **29**(7), 300, doi: 10.1007/s10965-022-03076-5.

Maia, B.S., Tjong, J. dan Sain, M., 2019, *Material characterization of recycled and virgin carbon fibers for transportation composites lightweighting*, *Materials Today Sustainability*, **5**, 100011, doi: 10.1016/j.mtsust.2019.100011.

Maier, C. dan Calafut, T., 1998, *Polypropylene: The Definitive User's Guide and Databook*, Plastics Design Library, Norwich, NY.

Mandal, D.K., Bhunia, H. dan Bajpai, P.K., 2019, *Thermal degradation kinetics of PP/PLA nanocomposite blends*, *Journal of Thermoplastic Composite Materials*, **32**(12), 1714–1730, doi: 10.1177/0892705718805130.

Mandal, D.K., Bhunia, H., Bajpai, P.K., Chaudhari, C.V., Dubey, K.A., Varshney, L. dan Kumar, A., 2021, *Preparation and characterization of polypropylene/polylactide blends and nanocomposites and their biodegradation study*, *Journal of Thermoplastic Composite Materials*, **34**(6), 725–744, doi: 10.1177/0892705719850601.

Marinosci, V.M., Helthuis, N.G.J., Chu, L., Grouve, W.J.B., De Rooij, M.B., Wijskamp, S. dan Akkerman, R., 2022, *The role of process induced polymer morphology on the fracture toughness of titanium–PEKK interfaces*, *Engineering Fracture Mechanics*, **268**, 108475, doi: 10.1016/j.engfracmech.2022.108475.

Mohan Bhasney, S., Kumar, A. dan Katiyar, V., 2020, *Microcrystalline cellulose, polylactic acid and polypropylene biocomposites and its morphological,*

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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

mechanical, thermal and rheological properties, *Composites Part B: Engineering*, **184**, 107717, doi: 10.1016/j.compositesb.2019.107717.

Muflikhun, M.A. dan Jamasri., 2022, *Proses Manufaktur dan Mekanika Komposit*, Gadjah Mada University Press.

Muñoz-Shugulí, C., Morán, D., Velásquez, E., López-Vilariño, J.M. dan López-de-Dicastillo, C., 2025, *Effect of Degradation During Multiple Primary Mechanical Recycling Processes on the Physical Properties and Biodegradation of Commercial PLA-Based Water Bottles*, *Polymers*, **17**(18), 2542, doi: 10.3390/polym17182542.

Ngaowthong, C., Borůvka, M., Běhálek, L., Lenfeld, P., Švec, M., Dangtungee, R., Siengchin, S., *dkk.*, 2019, *Recycling of sisal fiber reinforced polypropylene and polylactic acid composites: Thermo-mechanical properties, morphology, and water absorption behavior*, *Waste Management*, **97**, 71–81, doi: 10.1016/j.wasman.2019.07.038.

Omura, M., Tsukegi, T., Shirai, Y., Nishida, H. dan Endo, T., 2006, *Thermal Degradation Behavior of Poly(Lactic Acid) in a Blend with Polyethylene*, *Industrial & Engineering Chemistry Research*, American Chemical Society, **45**(9), 2949–2953, doi: 10.1021/ie051446x.

Oshima, S., Mamishin, A., Hojo, M., Nishikawa, M., Matsuda, N. dan Kanesaki, M., 2022, *High-resolution in situ characterization of micromechanisms in CFRP laminates under mode II loading*, *Engineering Fracture Mechanics*, **260**, 108189, doi: 10.1016/j.engfracmech.2021.108189.

Paik, P. dan Kar, K.K., 2008, *Kinetics of thermal degradation and estimation of lifetime for polypropylene particles: Effects of particle size*, *Polymer Degradation and Stability*, **93**(1), 24–35, doi: 10.1016/j.polymdegradstab.2007.11.001.

Pertuz, A.D., Díaz-Cardona, S. dan González-Estrada, O.A., 2020, *Static and fatigue behaviour of continuous fibre reinforced thermoplastic composites manufactured by fused deposition modelling technique*, *International Journal of Fatigue*, **130**, 105275, doi: 10.1016/j.ijfatigue.2019.105275.

Peterson, J.D., Vyazovkin, S. dan Wight, C.A., 2001, *Kinetics of the Thermal and Thermo-Oxidative Degradation of Polystyrene, Polyethylene and Poly(propylene)*, *Macromolecular Chemistry and Physics*, John Wiley & Sons, Ltd, **202**(6), 775–784, doi: 10.1002/1521-3935(20010301)202:6%3C775::AID-MACP775%3E3.0.CO;2-G.

Petrova, T.V., Tretyakov, I.V., Kireynov, A.V., Platonova, E.O., Ponomareva, P.F., Alexeeva, O.V., Solodilov, V.I., *dkk.*, 2023, *Carbon Fiber Reinforced Plastics Based on an Epoxy Binder with the Effect of Thermally Induced Self-Repair*, *Applied Sciences*, **13**(11), 6557, doi: 10.3390/app13116557.

Pingkarawat, K., Wang, C.H., Varley, R.J. dan Mouritz, A.P., 2014, *Mechanical properties of mendable composites containing self-healing thermoplastic agents*, *Composites Part A: Applied Science and Manufacturing*, **65**, 10–18, doi: 10.1016/j.compositesa.2014.05.015.

Pivsa-Art, S., Kord-Sa-Ard, J., Pivsa-Art, W., Wongpajan, R., O-Charoen, N., Pavasupree, S. dan Hamada, H., 2016, *Effect of Compatibilizer on PLA/PP Blend for Injection Molding*, *Energy Procedia*, **89**, 353–360, doi: 10.1016/j.egypro.2016.05.046.

Ploypetchara, N., Suppakul, P., Atong, D. dan Pechyen, C., 2014, *Blend of Polypropylene/Poly(lactic acid) for Medical Packaging Application: Physicochemical, Thermal, Mechanical, and Barrier Properties*, *Energy Procedia*, **56**, 201–210, doi: 10.1016/j.egypro.2014.07.150.

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Ranjbar, N., Mehrali, M., Behnia, A., Javadi Pordsari, A., Mehrali, M., Alengaram, U.J. dan Jumaat, M.Z., 2016, *A Comprehensive Study of the Polypropylene Fiber Reinforced Fly Ash Based Geopolymer*, disunting oleh Batchelor, W. *PLOS ONE*, **11**(1), e0147546, doi: 10.1371/journal.pone.0147546.

Reis, J.P., De Moura, M. dan Samborski, S., 2020, *Thermoplastic Composites and Their Promising Applications in Joining and Repair Composites Structures: A Review*, *Materials*, **13**(24), 5832, doi: 10.3390/ma13245832.

Rezwow, K., 2020, *Plastic and the automotive industry*, *Knauf Industries Automotive*, 21 Februari 2020, https://knaufautomotive.com/plastics-and-the-automotive-industry/ (diakses 29 Mei 2023).

Rigon, D., Florian, F., Ricotta, M., Ardengo, G., Trivillin, F. dan Meneghetti, G., 2021, *Fatigue behaviour of 3D printed virgin and recycled short-glass-fiber-reinforced and mineral-filled polypropylene*, *Procedia Structural Integrity*, **34**, 199–204, doi: 10.1016/j.prostr.2021.12.029.

Rosa-Ramírez, H.D.L., Aldas, M., Pavon, C., Dominici, F., Rallini, M., Puglia, D., Torre, L., *dkk.*, 2025, *Design and Characterization of Sustainable PLA-Based Systems Modified with a Rosin-Derived Resin: Structure–Property Relationships and Functional Performance*, *Biomimetics*, **10**(12), doi: 10.3390/biomimetics10120801.

Sable, S., Mandal, D.K., Ahuja, S. dan Bhunia, H., 2019, *Biodegradation kinetic modeling of oxo-biodegradable polypropylene/polylactide/nanoclay blends and composites under controlled composting conditions*, *Journal of Environmental Management*, **249**, 109186, doi: 10.1016/j.jenvman.2019.06.087.

Sakai, T., Shamsudim, N.S.B., Fukushima, R. dan Kageyama, K., 2021, *Effect of matrix crystallinity of carbon fiber reinforced polyamide 6 on static bending properties*, *Advanced Composite Materials*, Taylor & Francis, **30**(sup2), 71–84, doi: 10.1080/09243046.2020.1802805.

Senck, S., Scheerer, M., Revol, V., Plank, B., Hannesschläger, C., Gusenbauer, C. dan Kastner, J., 2018, *Microcrack characterization in loaded CFRP laminates using quantitative two- and three-dimensional X-ray dark-field imaging*, *Composites Part A: Applied Science and Manufacturing*, **115**, 206–214, doi: 10.1016/j.compositesa.2018.09.023.

Shirvanimoghaddam, K., Balaji, K.V., Yadav, R., Zabihi, O., Ahmadi, M., Adetunji, P. dan Naebe, M., 2021, *Balancing the toughness and strength in polypropylene composites*, *Composites Part B: Engineering*, **223**, 109121, doi: 10.1016/j.compositesb.2021.109121.

Shirvanimoghaddam, K., Hamim, S.U., Karbalaei Akbari, M., Fakhrhoseini, S.M., Khayyam, H., Pakseresht, A.H., Ghasali, E., *dkk.*, 2017, *Carbon fiber reinforced metal matrix composites: Fabrication processes and properties*, *Composites Part A: Applied Science and Manufacturing*, **92**, 70–96, doi: 10.1016/j.compositesa.2016.10.032.

Sin, Lee Tin, Rahmat, Abdul Razak dan Rahman, W.A.W.A., 2012, *Polylactic Acid, PLA Biopolymer Technology and Applications*, Elsevier.

Sin, Lee Tin dan Tueen, B.S., 2019, *Polylactic Acid, A Practical Guide for the Processing, Manufacturing and Applications of PLA*, Elsevier.

Song, L., Chi, W., Hao, Y., Ren, J., Yang, B., Cong, F., Li, Y., *dkk.*, 2024, *Improving the properties of polylactic acid/polypropylene carbonate blends through cardanol-induced compatibility enhancement*, *International Journal of Biological Macromolecules*, **258**, doi: 10.1016/j.ijbiomac.2023.128886.

Pengembangan Matriks Campuran Polypropylene dan Polylactic Acid melalui Pemrosesan Ulang yang
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Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

Staffa, L.H., Veronezc, I.D. dan Cruz, S.A., 2025, *Exploring interfacial tension role in the laminar morphology development in reactive compatibilized PP/EVOH*, *Journal of Materials Research*, **40**(1), 69–80, doi: 10.1557/s43578-024-01454-x.

Tang, W., Xu, J., Fan, Q., Li, W., Zhou, H., Liu, T., Guo, C., *dkk.*, 2022, *Rheological behavior and mechanical properties of ultra-high-filled wood fiber/polypropylene composites using waste wood sawdust and recycled polypropylene as raw materials*, *Construction and Building Materials*, **351**, 128977, doi: 10.1016/j.conbuildmat.2022.128977.

Toray., 2023, *Fabrics (Reinforcements) | PRODUCTS | Carbon Fiber Composite Materials | TORAY*, https://www.cf-composites.toray/products/fabrics/ (diakses 14 November 2022).

Vaganov, G., Didenko, A., Popova, E., Elokhovsky, V., Kamalov, A., Vaganov, V. dan Yudin, V., 2025, *The Impact of Molecular Weight on the Characteristics of Injection-Molded Partially Crystalline Thermoplastic Polyimide R-BAPB*, *Polymer Engineering & Science*, **65**(8), 4314–4322, doi: 10.1002/pen.27299.

Velghe, I., Buffel, B., Vandeginste, V., Thielemans, W. dan Desplentere, F., 2023, *Review on the Degradation of Poly(lactic acid) during Melt Processing*, *Polymers*, **15**(9), 2047, doi: 10.3390/polym15092047.

Venkatram, S., McCollum, J., Stingelin, N. dan Brettmann, B., 2023, *A close look at polymer degree of crystallinity* versus *polymer crystalline quality*, *Polymer International*, **72**(10), 855–860, doi: 10.1002/pi.6508.

Volynskii, A.L., Yarysheva, A.Y., Rukhlya, E.G., Yarysheva, L.M. dan Bakeev, N.F., 2014, *Specific features of structure and properties of solutions, melts and solid states of polymers in confined nanometric volumes*, *Russian Chemical Reviews*, **83**(11), 1003–1026, doi: 10.1070/RCR4428.

Volynskii, A.L., Yarysheva, A.Y., Rukhlya, E.G., Yarysheva, L.M. dan Bakeev, N.F., 2015, *Effect of spatial restrictions at the nanometer scale on structuring in glassy and crystalline polymers*, *Polymer Science - Series A*, **57**(5), 515–551, doi: 10.1134/S0965545X15050168.

Voudouris, G., Di Maio, D. dan Sever, I.A., 2020, *Experimental fatigue behaviour of CFRP composites under vibration and thermal loading*, *International Journal of Fatigue*, **140**, 105791, doi: 10.1016/j.ijfatigue.2020.105791.

Wang, X., Yu, W., Nie, Q., Guo, Y. dan Du, J., 2011, *A real-time study on the evolution of the degradation of polypropylene during mixing process*, *Journal of Applied Polymer Science*, John Wiley & Sons, Ltd, **121**(2), 1220–1243, doi: 10.1002/app.33795.

Wei, X. dan Bähr, R., 2024, *A comparative study of 3D printing with virgin and recycled polylactic acid filaments*, *CIRP Journal of Manufacturing Science and Technology*, **54**, 75–84, doi: 10.1016/j.cirpj.2024.08.007.

Weng, Y.-X., Jin, Y.-J., Meng, Q.-Y., Wang, L., Zhang, M. dan Wang, Y.-Z., 2013, *Biodegradation behavior of poly(butylene adipate-co-terephthalate) (PBAT), poly(lactic acid) (PLA), and their blend under soil conditions*, *Polymer Testing*, **32**(5), 918–926, doi: 10.1016/j.polymertesting.2013.05.001.

Williams, G., Trask, R. dan Bond, I., 2007, *A self-healing carbon fibre reinforced polymer for aerospace applications*, *Composites Part A: Applied Science and Manufacturing*, **38**(6), 1525–1532, doi: 10.1016/j.compositesa.2007.01.013.

Wisetkhamsai, K., Patthaveekongka, W. dan Arayapranee, W., 2023, *Effect of LNR-g-MMA on the Mechanical Properties and Lifetime Estimation of PLA/PP Blends*, *Polymers*, **15**(7), 1712, doi: 10.3390/polym15071712.

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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Wool, R.P., 2008, *Self-healing materials: a review*, *Soft Matter*, **4**(3), 400, doi: 10.1039/b711716g.

Yang, F. dan Pitchumani, R., 2002, *Healing of Thermoplastic Polymers at an Interface under Nonisothermal Conditions*, *Macromolecules*, **35**(8), 3213–3224, doi: 10.1021/ma010858o.

Yudhanto, A., Alfano, M. dan Lubineau, G., 2021, *Surface preparation strategies in secondary bonded thermoset-based composite materials: A review*, *Composites Part A: Applied Science and Manufacturing*, **147**, 106443, doi: 10.1016/j.compositesa.2021.106443.

Yudhanto, F., 2021, KOMPOSIT POLIMER-NANOSELULOSA DARI SERAT AGAVE CANTALA DENGAN EKSTRAKSI KIMIA DAN PROSES MEKANIS, PROGRAM STUDI DOKTOR TEKNIK MESIN DEPARTEMEN TEKNIK MESIN DAN INDUSTRI FAKULTAS TEKNIK Universitas Gadjah Mada.

Zawawi, E.Z.E., Hafizah, A.H.N., Romli, A.Z., Yuliana, N.Y. dan Bonnia, N.N., 2021, *Effect of nanoclay on mechanical and morphological properties of poly(lactide) acid (PLA) and polypropylene (PP) blends*, *Materials Today: Proceedings*, **46**, 1778–1782, doi: 10.1016/j.matpr.2020.07.612.

Zhang, J., Zhang, X., Zhang, F. dan Yu, S., 2017, *Solid-film sampling method for the determination of protein secondary structure by Fourier transform infrared spectroscopy*, *Analytical and Bioanalytical Chemistry*, **409**(18), 4459–4465, doi: 10.1007/s00216-017-0390-y.

Zovi, R.C., Mahmood, H., Dorigato, A., Fredi, G. dan Pegoretti, A., 2020, *Cyclic Olefin Copolymer Interleaves for Thermally Mendable Carbon/Epoxy Laminates*, *Molecules*, **25**(22), 5347, doi: 10.3390/molecules25225347.