

DAFTAR PUSTAKA

- [1] P. Kumar, P. Kumar, and S. Singh Thakur, "E-Waste and Hazardous Elements: A Comprehensive Study of Chemical Components and Environmental Threats," *Int. J. Innov. Sci. Res. Technol. IJISRT*, pp. 1074–1085, Oct. 2024, doi: 10.38124/ijisrt/IJISRT24OCT1008.
- [2] L. Li, L. Han, H. Hu, and R. Zhang, "A review on polymers and their composites for flexible electronics," *Mater. Adv.*, vol. 4, no. 3, pp. 726–746, 2023, doi: 10.1039/d2ma00940d.
- [3] M. Gong, L. Zhang, and P. Wan, "Polymer nanocomposite meshes for flexible electronic devices," *Prog. Polym. Sci.*, vol. 107, p. 101279, Aug. 2020, doi: 10.1016/j.progpolymsci.2020.101279.
- [4] R. A. Stottelaar, "The effect of humidity and strain on the electrical resistance of an epoxy based nanocomposite | TU Delft Repository," Delft University Of Technology, 2015. Accessed: Dec. 19, 2024. [Online]. Available: <https://repository.tudelft.nl/record/uuid:2b0d6c8e-f277-4250-a050-4b5cfa725485>
- [5] Nurin Firzannah Siregar, "Pengaruh Variasi Kelembaban Terhadap Nilai Sifat Listrik dari Film Komposit Polyvinyl Alcohol/Zinc Oxide/Polypyrrole," diploma, Universitas Andalas, 2023. Accessed: Jul. 16, 2024. [Online]. Available: <http://scholar.unand.ac.id/216148/>
- [6] H. M. J. Al-Ta'ii, Y. M. Amin, and V. Periasamy, "Humidity influenced capacitance and resistance of an Al/DNA/Al Schottky diode irradiated by alpha particles," *Sci. Rep.*, vol. 6, no. 1, p. 25519, May 2016, doi: 10.1038/srep25519.
- [7] V. V. Tran, S. Lee, D. Lee, and T.-H. Le, "Recent Developments and Implementations of Conductive Polymer-Based Flexible Devices in Sensing Applications," *Polymers*, vol. 14, no. 18, Art. no. 18, Sep. 2022, doi: 10.3390/polym14183730.
- [8] G. Scandurra, A. Arena, and C. Ciofi, "A Brief Review on Flexible Electronics for IoT: Solutions for Sustainability and New Perspectives for Designers," *Sensors*, vol. 23, no. 11, Art. no. 11, Jun. 2023, doi: 10.3390/s23115264.
- [9] Fortune Business Insights, "Flexible Electronics Market Size, Share, Revenue, Forecast 2032." Accessed: Jan. 04, 2025. [Online]. Available: <https://www.fortunebusinessinsights.com/flexible-electronics-market-109105>
- [10] R. Hsissou, R. Seghiri, Z. Benzekri, M. Hilali, M. Rafik, and A. Elharfi, "Polymer composite materials: A comprehensive review," *Compos. Struct.*, vol. 262, p. 113640, Apr. 2021, doi: 10.1016/j.compstruct.2021.113640.

- [11] M Abiyi Bermantio, "Perubahan Sifat Listrik dari Fim Komposit Disebabkan Variasi Kelembaban," diploma, Universitas Andalas, 2021. Accessed: Jul. 16, 2024. [Online]. Available: <http://scholar.unand.ac.id/96287/>
- [12] W. R. Fadila and M. Nasir, "Pengaruh Heat Treatment Pada Sifat Kristal, Listrik Dan Optik Nanokomposit ZnO/Pva," Jun. 2022.
- [13] E. Gharoy Ahangar, M. H. Abbaspour-Fard, N. Shahtahmassebi, M. Khojastehpour, and P. Maddahi, "Preparation and Characterization of PVA/ZnO Nanocomposite: Physical Properties of PVA/ZnO," *J. Food Process. Preserv.*, vol. 39, no. 6, pp. 1442–1451, Dec. 2015, doi: 10.1111/jfpp.12363.
- [14] J. Michael, Z. Qifeng, and W. Danling, "Titanium carbide MXene: Synthesis, electrical and optical properties and their applications in sensors and energy storage devices," *Nanomater. Nanotechnol.*, vol. 9, p. 184798041882447, Jan. 2019, doi: 10.1177/1847980418824470.
- [15] A. Zamhuri, G. P. Lim, N. L. Ma, K. S. Tee, and C. F. Soon, "MXene in the lens of biomedical engineering: synthesis, applications and future outlook," *Biomed. Eng. OnLine*, vol. 20, no. 1, p. 33, Apr. 2021, doi: 10.1186/s12938-021-00873-9.
- [16] R. Liu and W. Li, "High-Thermal-Stability and High-Thermal-Conductivity $Ti_3C_2T_x$ MXene/Poly(vinyl alcohol) (PVA) Composites," *ACS Omega*, vol. 3, no. 3, pp. 2609–2617, Mar. 2018, doi: 10.1021/acsomega.7b02001.
- [17] Z. Hadi, J. K. Yeganeh, Y. Zare, M. T. Munir, and K. Y. Rhee, "Predicting of electrical conductivity for Polymer-MXene nanocomposites," *J. Mater. Res. Technol.*, vol. 28, pp. 4229–4238, Jan. 2024, doi: 10.1016/j.jmrt.2024.01.014.
- [18] R. Gautam, N. Marriwala, and R. Devi, "A review: Study of Mxene and graphene together," *Meas. Sens.*, vol. 25, p. 100592, Feb. 2023, doi: 10.1016/j.measen.2022.100592.
- [19] N. Grishkewich, N. Mohammed, J. Tang, and K. C. Tam, "Recent advances in the application of cellulose nanocrystals," *Curr. Opin. Colloid Interface Sci.*, vol. 29, pp. 32–45, May 2017, doi: 10.1016/j.cocis.2017.01.005.
- [20] A. S. Levitt, M. Alhabeab, C. B. Hatter, A. Sarycheva, G. Dion, and Y. Gogotsi, "Electrospun MXene/carbon nanofibers as supercapacitor electrodes," *J. Mater. Chem. A*, vol. 7, no. 1, pp. 269–277, 2019, doi: 10.1039/C8TA09810G.
- [21] Ł. Dybowska-Sarapuk, W. Sosnowicz, A. Grzeczko, J. Krzemiński, and M. Jakubowska, "Ultrasonication effects on graphene composites in neural cell cultures," *Front. Mol. Neurosci.*, vol. 15, p. 992494, Sep. 2022, doi: 10.3389/fnmol.2022.992494.
- [22] M. N. F. A. Malek *et al.*, "Ultrasonication: a process intensification tool for methyl ester synthesis: a mini review," *Biomass Convers. Biorefinery*, vol.

- 13, no. 2, pp. 1457–1467, Jan. 2023, doi: 10.1007/s13399-020-01100-6.
- [23] Z. Wu *et al.*, “Ultrasound-assisted preparation of chitosan/nano-silica aerogel/tea polyphenol biodegradable films: Physical and functional properties,” *Ultrason. Sonochem.*, vol. 87, p. 106052, Jun. 2022, doi: 10.1016/j.ultsonch.2022.106052.
- [24] T. S. Soliman, A. M. Rashad, I. A. Ali, S. I. Khater, and S. I. Elkalashy, “Investigation of Linear Optical Parameters and Dielectric Properties of Polyvinyl Alcohol/ZnO Nanocomposite Films,” *Phys. Status Solidi A*, vol. 217, no. 19, p. 2000321, Oct. 2020, doi: 10.1002/pssa.202000321.
- [25] Z. Ling *et al.*, “Flexible and conductive MXene films and nanocomposites with high capacitance,” *Proc. Natl. Acad. Sci.*, vol. 111, no. 47, pp. 16676–16681, Nov. 2014, doi: 10.1073/pnas.1414215111.
- [26] Zhang-Shuo L., Ji L., Yang D., Xiao-Feng L., Zhong-Zhen Y., and Hao-Bin Z., “Bioinspired Ultrathin MXene/CNC Composite Film for Electromagnetic Interference Shielding,” *J. Inorg. Mater.*, p. 148, 2019, doi: 10.15541/jim20190148.
- [27] P. Sobolčiak *et al.*, “2D Ti₃C₂T_x (MXene)-reinforced polyvinyl alcohol (PVA) nanofibers with enhanced mechanical and electrical properties,” *PLOS ONE*, vol. 12, no. 8, p. e0183705, Aug. 2017, doi: 10.1371/journal.pone.0183705.
- [28] D. K. Rajak, D. D. Pagar, R. Kumar, and C. I. Pruncu, “Recent progress of reinforcement materials: a comprehensive overview of composite materials,” *J. Mater. Res. Technol.*, vol. 8, no. 6, pp. 6354–6374, Nov. 2019, doi: 10.1016/j.jmrt.2019.09.068.
- [29] V. S. Sulaberidze, V. D. Mushenko, V. A. Mikheev, and E. A. Skorniakova, “Mechanical properties of new functional composite materials based on polymeric binders,” *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 537, no. 2, p. 022017, May 2019, doi: 10.1088/1757-899X/537/2/022017.
- [30] I. Prabowo and M. Chalid, “Optimalisasi Sifat Mekanik Biokomposit PLA dengan Serat Arenga Pinnata,” vol. 1, no. 2, 2021.
- [31] R. Fuazzidin, R. D. Anjani, and V. Naubnome, “Pengaruh Fraksi Volume Komposit Serat Pelepah Pisang Kepok Dengan Polyester Dan Filler Terhadap Sifat Mekanik,” vol. 11, no. 2, 2023.
- [32] M. Yani and Faisal Lubis, “Pembuatan dan Penyelidikan Perilaku Mekanik Komposit Diperkuat Serat Limbah Plastik Akibat Beban Lentutan,” *Mekanik*, vol. 4, no. 2, Nov. 2018.
- [33] M. Lay, I. González, J. A. Tarrés, N. Pellicer, K. N. Bun, and F. Vilaseca, “High electrical and electrochemical properties in bacterial cellulose/polypyrrole membranes,” *Eur. Polym. J.*, vol. 91, pp. 1–9, Jun. 2017, doi: 10.1016/j.eurpolymj.2017.03.021.
- [34] A. Firdaus, A. Tjahjono, and S. A. Saptari, “Analisis Pengaruh Bentuk Filler Pada Komposit Batang Bambu Terhadap Nilai Kekerasan (Hardness Shore

- D),” *Al-Fiziya J. Mater. Sci. Geophys. Instrum. Theor. Phys.*, vol. 1, no. 2, pp. 1–6, Apr. 2019, doi: 10.15408/fiziya.v1i2.9506.
- [35] A. Sjahriza, S. Herlambang, and I. F. Wati, “Modifikasi Karakteristik Kuat Tarik pada Komposit Film Poli(Vinil Piroolidon) dan Karagenan Melalui Pembentukan Komposit Karbon Nano Dot,” *Al-Kim.*, vol. 5, no. 2, pp. 52–56, 2019, doi: 10.15575/ak.v5i2.3756.
- [36] S. Ningaraju and H. B. Ravikumar, “Studies on electrical conductivity of PVA/graphite oxide nanocomposites: a free volume approach,” *J. Polym. Res.*, vol. 24, no. 1, p. 11, Jan. 2017, doi: 10.1007/s10965-016-1176-1.
- [37] Y. Pan *et al.*, “Flammability, thermal stability and mechanical properties of polyvinyl alcohol nanocomposites reinforced with delaminated $Ti_3C_2T_x$ (MXene),” *Polym. Compos.*, vol. 41, no. 1, pp. 210–218, Jan. 2020, doi: 10.1002/pc.25361.
- [38] K. T. Shalumon, K. H. Anulekha, S. V. Nair, S. V. Nair, K. P. Chennazhi, and R. Jayakumar, “Sodium alginate/poly(vinyl alcohol)/nano ZnO composite nanofibers for antibacterial wound dressings,” *Int. J. Biol. Macromol.*, vol. 49, no. 3, pp. 247–254, Oct. 2011, doi: 10.1016/j.ijbiomac.2011.04.005.
- [39] H. Assaedi, “The role of nano- $CaCO_3$ in the mechanical performance of polyvinyl alcohol fibre-reinforced geopolymer composites,” *Compos. Interfaces*, vol. 28, no. 5, pp. 527–542, May 2021, doi: 10.1080/09276440.2020.1793096.
- [40] X. Tang and S. Alavi, “Recent advances in starch, polyvinyl alcohol based polymer blends, nanocomposites and their biodegradability,” *Carbohydr. Polym.*, vol. 85, no. 1, pp. 7–16, Apr. 2011, doi: 10.1016/j.carbpol.2011.01.030.
- [41] H. Abrial *et al.*, “Effect of ultrasonication duration of polyvinyl alcohol (PVA) gel on characterizations of PVA film,” *J. Mater. Res. Technol.*, vol. 9, no. 2, pp. 2477–2486, Mar. 2020, doi: 10.1016/j.jmrt.2019.12.078.
- [42] M. J. Simanjuntak, “Studi Film Polyvinil Alkohol (PVA) Dimodifikasi dengan Acrylamide (AAm) sebagai Material Sensitif terhadap Kelembaban,” diploma, Universitas Indonesia, Depok, 2008. Accessed: Aug. 01, 2024. [Online]. Available: <https://lib.ui.ac.id>
- [43] V. Harahap and S. Sidabutar, “Sintesis Dan Sifat Magnetik Komposit BaFe₁₂O₁₉/ZnO Terhadap Aplikasi Elektronik Media Perekam Dan Absorben,” *2-TRIK TUNAS-TUNAS Ris. Kesehat.*, vol. 10, no. 2, Art. no. 2, May 2020, doi: 10.33846/2trik10203.
- [44] D. A. Daratika, “Sintesis Nanopartikel Zn_{1-x}Cu_xO Dengan Metode Kopersipitasi,” Undergraduate, Institut Teknologi Sepuluh Nopember, 2016. Accessed: Aug. 02, 2024. [Online]. Available: <https://repository.its.ac.id/75796/>
- [45] I. Husein, A. Maddu, H. Syafutra, and dan Ismangil, “Uji Konduktivitas

- Listrik dan Dielektrik Film Tipis Lithium Tantalate (LiTaO₃) Yang Didadah Niobium Pentaoksida (Nb₂O₅) Menggunakan Metode Chemical Solution Deposition,” presented at the Prosiding Seminar Nasional Fisika 2010, Bogor: Institut Pertanian Bogor, Aug. 2010.
- [46] N. W. Sari, M. Y. Fajri, and A. Wilapangga, “Analisis Fitokimia dan Gugus Fungsi Dari Ekstrak Etanol Pisang Goroho Merah (*Musa Acuminata* (L)),” *Indones. J. Biotechnol. Biodivers.*, vol. 2, no. 1, Art. no. 1, Jul. 2019, doi: 10.47007/ijobb.v2i1.26.
- [47] V. K. H. Bui *et al.*, “A review on zinc oxide composites for energy storage applications: solar cells, batteries, and supercapacitors,” *J. Compos. Compd.*, vol. 3, no. 8, Art. no. 8, Sep. 2021, doi: 10.52547/jcc.3.3.6.
- [48] M. Saeed, H. M. Marwani, U. Shahzad, A. M. Asiri, and M. M. Rahman, “Recent Advances, Challenges, and Future Perspectives of ZnO Nanostructure Materials Towards Energy Applications,” *Chem. Rec. N. Y. N*, vol. 24, no. 1, p. e202300106, Jan. 2024, doi: 10.1002/tcr.202300106.
- [49] K. H. Tan, L. Samylingam, N. Aslfattahi, R. Saidur, and K. Kadirgama, “Optical and conductivity studies of polyvinyl alcohol-MXene (PVA-MXene) nanocomposite thin films for electronic applications,” *Opt. Laser Technol.*, vol. 136, p. 106772, Apr. 2021, doi: 10.1016/j.optlastec.2020.106772.
- [50] U. B. Surono, “Analisa Sifat Fisis dan Mekanis Komposit Serat Ijuk Dengan Bahan Matrik Poliester,” *ReTII*, 2016, Accessed: Jul. 21, 2024. [Online]. Available: //journal.itny.ac.id/index.php/ReTII/article/view/470
- [51] V. Natu, M. Clites, E. Pomerantseva, and M. W. Barsoum, “Mesoporous MXene powders synthesized by acid induced crumpling and their use as Na-ion battery anodes,” *Mater. Res. Lett.*, vol. 6, no. 4, pp. 230–235, Apr. 2018, doi: 10.1080/21663831.2018.1434249.
- [52] M. Xin, J. Li, Z. Ma, L. Pan, and Y. Shi, “MXenes and Their Applications in Wearable Sensors,” *Front. Chem.*, vol. 8, p. 297, Apr. 2020, doi: 10.3389/fchem.2020.00297.
- [53] Y. Wang *et al.*, “Engineering 3D Ion Transport Channels for Flexible MXene Films with Superior Capacitive Performance,” *Adv. Funct. Mater.*, vol. 29, no. 14, p. 1900326, Apr. 2019, doi: 10.1002/adfm.201900326.
- [54] S. K. Amit, D. Gomez-Maldonado, T. Bish, M. S. Peresin, and V. A. Davis, “Properties of APTES-Modified CNC Films,” *ACS Omega*, vol. 9, no. 14, pp. 16572–16580, Apr. 2024, doi: 10.1021/acsomega.4c00439.
- [55] V. Hynninen, J. Patrakka, and Nonappa, “Methylcellulose–Cellulose Nanocrystal Composites for Optomechanically Tunable Hydrogels and Fibers,” *Materials*, vol. 14, no. 18, Art. no. 18, Jan. 2021, doi: 10.3390/ma14185137.
- [56] M. Pagliaro *et al.*, “Application of nanocellulose composites in the environmental engineering as a catalyst, flocculants, and energy storages: a

- review,” *J. Compos. Compd.*, vol. 3, no. 7, Art. no. 7, Jun. 2021, doi: 10.52547/jcc.3.2.5.
- [57] S. Singh, S. Bhardwaj, P. Tiwari, K. Dev, K. Ghosh, and P. K. Maji, “Recent advances in cellulose nanocrystals-based sensors: a review,” *Mater. Adv.*, vol. 5, no. 7, pp. 2622–2654, Apr. 2024, doi: 10.1039/D3MA00601H.
- [58] A. B. Rashid *et al.*, “Synthesis, Properties, Applications, and Future Prospective of Cellulose Nanocrystals,” *Polymers*, vol. 15, no. 20, Art. no. 20, Jan. 2023, doi: 10.3390/polym15204070.
- [59] N. H. Ince, G. Tezcanli, R. K. Belen, and İ. G. Apikyan, “Ultrasound as a catalyzer of aqueous reaction systems: the state of the art and environmental applications,” *Appl. Catal. B Environ.*, vol. 29, no. 3, pp. 167–176, Feb. 2001, doi: 10.1016/S0926-3373(00)00224-1.
- [60] A. Akhoondi, H. Ghaebi, L. Karuppasamy, M. M. Rahman, and P. Sathishkumar, “Recent advances in hydrogen production using MXenes-based metal sulfide photocatalysts,” *Synth. Sinter.*, vol. 2, no. 1, pp. 37–54, Mar. 2022, doi: 10.53063/synsint.2022.21106.
- [61] T. Ji *et al.*, “Effects of Ultrasonication Time on the Properties of Polyvinyl Alcohol/Sodium Carboxymethyl Cellulose/Nano-ZnO/Multilayer Graphene Nanoplatelet Composite Films,” *Nanomaterials*, vol. 10, no. 9, Art. no. 9, Sep. 2020, doi: 10.3390/nano10091797.
- [62] T. S. Dewi and N. P. Putri, “Pengaruh Waktu Ultrasonikasi Terhadap Karakteristik Elektroda Superkapasitor Berbahan Dasar Tempurung Kelapa,” *Inov. Fis. Indones.*, vol. 8, no. 1, 2019, doi: 10.26740/ifi.v8n1.p%p.
- [63] B. Delmifiana and Astuti -, “Pengaruh Sonikasi Terhadap Struktur dan Morfologi Nanopartikel Magnetik yang Disintesis Dengan Metode Kopresipitasi,” *J. Fis. Unand*, vol. 2, no. 3, Art. no. 3, Nov. 2013, doi: 10.25077/jfu.2.3.%p.2013.
- [64] N. K. Sari and A. Muttaqin, “Pengaruh Waktu Sonikasi terhadap Konduktivitas Listrik Zeolit Berbahan Abu Dasar Batubara Menggunakan Metode Peleburan Alkali Hidrotermal,” *J. Fis. Unand*, vol. 5, no. 4, Art. no. 4, Oct. 2016, doi: 10.25077/jfu.5.4.322-326.2016.
- [65] S. Indarwati, S. M. B. Respati, and D. Darmanto, “Kebutuhan Daya Pada Air Conditioner Saat Terjadi Perbedaan Suhu dan Kelembaban,” *J. Ilm. Momentum*, vol. 15, no. 1, Art. no. 1, May 2019, doi: 10.36499/jim.v15i1.2666.
- [66] J. Bhadra, A. Popelka, A. Abdulkareem, M. Lehocky, P. Humpolicek, and N. Al-Thani, “Effect of humidity on the electrical properties of the silver-polyaniline/polyvinyl alcohol nanocomposites,” *Sens. Actuators Phys.*, vol. 288, pp. 47–54, Apr. 2019, doi: 10.1016/j.sna.2019.01.012.
- [67] I. Irzaman, R. Erviansyah, H. Syafutra, A. Maddu, and S. Siswadi, “Studi Konduktivitas Listrik Film Tipis Ba_{0.25}Sr_{0.75}TiO₃ Yang Didadah Ferium

- Oksida (BFST) Menggunakan Metode Chemical Solution Deposition,” *Berk. Fis.*, vol. 13, no. 1, pp. 33–38, Mar. 2012.
- [68] D. Rahmadiawan *et al.*, “A Novel Highly Conductive, Transparent, and Strong Pure-Cellulose Film from TEMPO-Oxidized Bacterial Cellulose by Increasing Sonication Power,” *Polymers*, vol. 15, no. 3, p. 643, Jan. 2023, doi: 10.3390/polym15030643.
- [69] D. Wang, D. Zhang, P. Li, Z. Yang, Q. Mi, and L. Yu, “Electrospinning of Flexible Poly(vinyl alcohol)/MXene Nanofiber-Based Humidity Sensor Self-Powered by Monolayer Molybdenum Diselenide Piezoelectric Nanogenerator,” *Nano-Micro Lett.*, vol. 13, no. 1, p. 57, Dec. 2021, doi: 10.1007/s40820-020-00580-5.
- [70] S. Martadi, M. A. Sulthoni, G. Wiranto, A. Surawijaya, and I. D. P. Herminda, “Design and Fabrication of PVA-Based Relative Humidity Sensors Using Thick Film Technology,” in *2019 International Symposium on Electronics and Smart Devices (ISESD)*, Oct. 2019, pp. 1–4. doi: 10.1109/ISESD.2019.8909519.
- [71] K. Xu, T. Peng, B. Zhang, Y. Wu, Z. Huang, and Q. Guan, “Zinc oxide bridges the nanofillers to enhance the wear resistance and stability of triboelectric nanogenerators,” *Chem. Eng. J.*, vol. 493, p. 152532, Aug. 2024, doi: 10.1016/j.cej.2024.152532.
- [72] H. S. Mansur, R. L. Oréface, and A. A. P. Mansur, “Characterization of poly(vinyl alcohol)/poly(ethylene glycol) hydrogels and PVA-derived hybrids by small-angle X-ray scattering and FTIR spectroscopy,” *Polymer*, vol. 45, no. 21, pp. 7193–7202, Sep. 2004, doi: 10.1016/j.polymer.2004.08.036.
- [73] M. Asrofi, H. Abral, Y. K. Putra, S. Sapuan, and H.-J. Kim, “Effect of duration of sonication during gelatinization on properties of tapioca starch water hyacinth fiber biocomposite,” *Int. J. Biol. Macromol.*, vol. 108, pp. 167–176, Mar. 2018, doi: 10.1016/j.ijbiomac.2017.11.165.
- [74] K. Srinivas and K. K. Pandey, “Effect of Heat Treatment on Color Changes, Dimensional Stability, and Mechanical Properties of Wood,” *J. Wood Chem. Technol.*, vol. 32, no. 4, pp. 304–316, Oct. 2012, doi: 10.1080/02773813.2012.674170.
- [75] A. R. Santos and J. C. Viana, “The Development of a Flexible Humidity Sensor Using MWCNT/PVA Thin Films,” *Nanomaterials*, vol. 14, no. 20, Art. no. 20, Oct. 2024, doi: 10.3390/nano14201653.