International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972
Volume 7 Issue 22 (September 2025) PP. 169-178
DOI 10.35631/IJIREV.722012

INTERNATIONAL JOURNAL OF INNOVATION AND INDUSTRIAL REVOLUTION (IJIREV)
www.ijirev.com

CHARACTERISTIC OF PALM EMPTY FRUIT BUNCH (PEFB) FIBERS REINFORCED LOW-DENSITY POLYETHYLENE (LDPE) FOR PEFB/LDPE POLYMER COMPOSITES

Noraini Marsi[1,2*], Nur Huda Jailani[1], Nik Normunira Mat Hassan[1], Mohamad Mohshein Hashim[3], Efil Yusrianto[4], Asmadi Md-Said[5]

[1] Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, Edu Hub Pagoh, 84600 Muar, Johor, Malaysia
Email: mnoraini@uthm.edu.my, hudajailani8@gmail.com, munira@uthm.edu.my
[2] Advanced Manufacturing and Material Centre (AMMC), Institute of Integrated Engineering, Universiti Tun Hussein Onn Malaysia, 86400 Batu Pahat, Johor, Malaysia
[3] My Flexitank Industries Sdn Bhd, Plot 3 & 4, Kawasan Perusahaan LPK Fasa 3, Jln PKNK 3/7, Perusahaan LPK Fasa 3, 08000 Sungai Petani, Kedah
Email: mohsheinhashim2312@gmail.com
[4] Universitas Islam Negeri Imam Bonjol Padang, Jl. Prof. Mahmud Yunus Lubuk Lintah, Anduring, Kec. Kuranji, Padang, 25153 Sumatera Barat, Indonesia
Email: efil.yusrianto@gmail.com
[5] Angkasa Kowaris Plastics Sdn Bhd, Lot 15796 Block A&B, Jalan Kebun Tambahan, Seksyen 32, 40460 Shah Alam, Selangor, Malaysia
Email: asmadi_mdsaid@yahoo.com
[*] Corresponding Author

Article Info:

Article history:
Received date: 30.06.2025
Revised date: 21.07.2025
Accepted date: 14.08.2025
Published date: 01.09.2025

To cite this document:

Marsi, N., Jailani, N. H., Mat Hassan, N. N., Hashim, M. M., Yusrianto, E., & Md-Said, A. (2025). Characteristic Of Palm Empty Fruit Bunch (PEFB) Fibers Reinforced Low-Density Polyethylene (LDPE) For PEFB/LDPE Polymer Composites.

Abstract:

The study presents the characteristic of Palm Empty Fruit Bunch (PEFB) fibers reinforced Low-Density Polyethylene (LDPE) for PEFB/LDPE polymer composites into deck panel application. This research aims to formulate the different composition ratios of PEFB fibers reinforced for PEFB/LDPE polymer composites into deck panel application. The importance of this study is to fabricate a new material environmentally polymer composite material from waste resources of oil palm such as PEFB fibers abundant in Malaysia. This research includes the different composition ratios of PEFB fibers, which are 0.1, 0.2, 0.3, 0.4, and 0.5 (wt/wt%) reinforced LDPE plastic waste mixed with epoxy resin and hardener with a ratio of 3:1. The waste fiber from PEFB was grinded into 0.5 mm-1.5 mm ± 0.05 to produce fine fibers with an 18000-rpm speed grinder machine. The mixture was poured into a mold and cured for 48 hours at room temperature. The physical and mechanical testing was conducted on the sample with different composition ratios of PEFB fibers. It is revealed that the greater ratio of PEFB fibers, 0.5 (wt/wt%), produced the

International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972
Volume 7 Issue 22 (September 2025) PP. 169-178
DOI 10.35631/IJIREV.722012

International Journal of Innovation and Industrial Revolution, 7 (22), 169-178.

DOI: 10.35631/IJIREV.722012

lowest density of 1.048 g/cm^3 and maximum porosity up to 60%. The tensile strength test showed 0.4 (wt/wt%) of PEFB fibers reinforced with LDPE plastic waste had the highest tensile strength at 6.20 MPa that exerted 360.89 N of force. It can be concluded that the optimal composition for deck panel application is 0.4 (wt./wt.%) PEFB/LDPE polymer composites.

Keywords:

PEFB, LDPE, Polymer, Composites, Panel, Strength

Introduction

Currently, Malaysia is the world's second-largest palm oil producer and the world's largest exporter of palm oil. In 2019, it exported roughly 17.4 million metric tonnes of palm oil and palm-derived products. Exports total approximately 67.5 billion Malaysian ringgits. In total, Malaysia's palm oil industry contributed approximately 36.9 billion ringgits to the country's gross domestic product (Parveez, 2024). The PEFB fibres are either burned or discarded. These practices lead to environmental pollution by emitting gases containing particulate matter such as tar and soot particles. The indiscriminate disposal of PEFB fibres adds to the atmosphere's methane emissions.

Global plastic production climbed from 1.5 million tonnes per year in 1950 to 275 million tonnes in 2012 and 359 million tonnes in 2018. Countries dump between 4.8 million and 12.7 million tonnes of plastic trash into the oceans each year. Plastic has a low recovery rate compared to other materials such as glass, paper, iron, and aluminium (Pilapitiya, 2024). Therefore, the lifespan of plastic can be optimized by reusing and recycling items regularly to reduce the production of new plastic. The usage of plastic waste will minimize the use of non-renewable sources and can create an eco-friendly product. PEFB fibers and LDPE plastic waste are used in this study as raw materials to formulate the different composition ratios of PEFB fibers reinforced LDPE for PEFB/LDPE polymer composites into deck panel application.

Literature Review

Polymer composite is a new alternative structural material that combines natural fiber and petrochemical-based polymer. The higher number of natural fibers in a product can reduce the usage of petroleum-based polymers. Palm Empty Fruit Bunch (PEFB) fibers are a part of palm oil residue waste (Kaewtrakulchai, 2024). Low-Density Polyethylene (LDPE) plastic is hugely attractive as a plastic manufacturing material to customer across a range of sectors and widely used in packaging for both food and non-food purposes, such as foils, trays, and plastic bags (Krehula, 2024). Thus, LDPE is ideal for mass production and large product batch runs as it requires very little energy and investment to produce, and it also can be recycled. The use of PEFB fibers reinforced LDPE in polymer composites for the production of low-cost and functional products was rapidly growing.

Palm Empty Fruit Bunches (PEFB)

The palm fruit is embedded in a fruit bunch. An empty fruit bunch is obtained when the oil is extracted from the palm fruit leaving a bunch of fibers. According to SIRIM Berhad, Malaysia, an oil palm mill produces 23% of PEFB for every ton of Fresh Fruit Bunch (FFB) (Ghazalli, 2023). The amount of waste generated by the oil palm industry is growing as the industry grows. Therefore, the use of these wastes as compost is considered as to overcome their negative impacts and recycle them to produce a useful by product for agriculture. Table 1

International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972
Volume 7 Issue 22 (September 2025) PP. 169-178
DOI 10.35631/IJIREV.722012
tabulated the mechanical and physical properties of PEFB fibers (Faizi, 2019). As a result, PEFB is commercially marketed to produce mattresses, car seats, insulation, and composites.

Table 1: Mechanical And Physical Properties of PEFB Fibers (Faizi, 2019)

Categories	Applications
Tensile Strength (MPa)	60-81
Young Modulus (GPa)	1-9
Density (g/cm3)	0.7-1.55
Diameter (µm)	250-610
Elongation at break (%)	8-18

Low-Density Polyethylene (LDPE)

Low-density polyethylene (LDPE) is a thermoplastic derived from the ethylene monomer. The LDPE structure that was the first grade of polyethylene, manufactured in 1933 by Imperial Chemical Industries (ICI) using a high pressure free radical polymerization process (Abdullah, 2021). Table 2 shows the properties of LDPE (Kormin, 2017). LDPE is commonly used in the production of containers, dispensing tubes, wash bottles, tubing, plastic parts for computer hardware, and molded laboratory equipment. Its most popular use is in plastic bags.

Table 2: Properties of LDPE (Kormin, 2017)

Categories	Applications
Melting Point	105 to 115°C
Density	0.910–0.940 g/cm3
Chemical Resistance	Good resistance to alcohols, dilute alkalis and acids
Temperature Resistance	up to 80°C - 95°C for shorter times
Cost	have low cost polymer with good processability
Impact Strength	high impact strength at low temperature
Electrical	Excellent electrical insulating properties
Physical	Transparent in thin film form

Polymer Composites

Polymer Matrix Composites (PMCs) are very common due to their low cost and simple fabrication methods. The use of nonreinforced polymers as structure materials is restricted by their poor mechanical properties, namely strength, modulus, and impact resistance (Phiri, 2024). The reinforcement of polymers by a tight fibrous network enables the fabrication of PMCs due to their characteristics on high specific strength, high specific stiffness, high fracture resistance, good abrasion resistance, good impact resistance, good corrosion resistance, good fatigue resistance, and have a low cost (Thanikodi, 2024). Polymer composites have a wide application due to their valued of low cost and fabrication processes. Table 3 shows the application of polymer composites in different categories (Markandan, 2023).

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 7 Issue 22 (September 2025) PP. 169-178
DOI 10.35631/IJIREV.722012

Table 3: Application Of Polymer Composites on Different Categories (Markandan, 2023)

Categories	Applications
Automotive Industries	body panels, leaf springs, driveshaft, bumper, and doors
Aircraft Industries	Parts for military aircraft, space shuttles, and satellite systems
Marine	Fiberglass boat bodies, Canoes and Kayaks
Sports Goods	Footwear, sports equipment and other sporting goods
Biomedical	Medical implants, orthopaedic devices, MRI Scanners, X-Ray
Electrical	Panels, housing, switchgear, insulators, and connectors.
Protective Equipment	Bulletproof vests and another armor.
Industrial	Pressure vessels, pump housing, valves, Blades, and blower
Structural	Bridges, Beams and Cranes

Deck Panel

A deck is a flat, weight-bearing surface in architecture similar to a board, but is commonly located externally, sometimes higher from the ground, and is generally attached to a structure. Composite decking is a combination of two components, usually wood pulp and recycled material such as water bottles or plastic bags, that has come on the market in response to environmental and longevity issues (Jamal, 2024). Proponents of composite decking have welcomed this as a much-needed advancement as to reduce tree logging for new decks.

Methodology

The PEFB fibers and LPDE plastic waste were used as the raw material for PEFB/LDPE polymer composites into deck panel application. The preparation of samples was involved the different compositions of PEFB fibers reinforced LPDE plastic waste mixed with epoxy resin and hardener. Figure 1 shows the PEFB fibers, LDPE plastic waste, Epoxy resin (DER-331) and hardener (Jointment 905-3S). The PEFB fibers includes cellulose, hemicellulose, and lignocellulose chemical blocks and is currently used as a biofuel, fertilizer, and compost production, but its future use is undefined (Faizi, 2019).

From the previous study, the mechanical and physical properties of PEFB fiber are listed in Table 1. The use of cellulose as a polymer has received many attentions because it contains non-toxic materials, which is biodegradable that does not emit any pollutants into the atmosphere. Low-density polyethylene (LDPE) plastic waste was collected and repurposed to create new and useful plastic items through the plastic recycling process. The recycling process is the most effective method for dealing with waste polymer products that are not harmful to the environment (Ojo, 2023).

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 7 Issue 22 (September 2025) PP. 169-178
DOI 10.35631/IJIREV.722012

(a) (b) (c) (d)

Figure 1: (a) PEFB Fibers (b) LDPE Plastic Waste (c) Epoxy Resin (DER-331) (d) Hardener (Jointment 905-3S)

Epoxy resin is a type of resin with stiff mechanical properties, good chemical resistance, and high adhesive strength, which make it extremely useful for a wide variety of applications and was utilized as convertible coatings in the paint industry (Lu, 2022). Meanwhile, A hardener is a substance that is added to many kinds of mixtures and it is used in certain mixtures to maximize the resilience of the mixture until it has been set (Achmad, 2021). During the mixing phase, a hardener may be either a reactant or a catalyst in the chemical reaction. The preparation of samples was involved the different compositions of PEFB fibers reinforced LPDE plastic waste mixed with epoxy resin and hardener. The composition ratio of PEFB/LDPE polymer composite as referred to Table 4.

The sample preparation processes were involved drying process, grinding process, refining process, weighting process, mixing process and curing process. The PEFB fiber was dried for five days at a temperature of 30°C to eliminate any moisture content from the PEFB fibers and ensure the quality of the fibers sustain and were grinded using an 18000 rpm of the high-speed grinder into a fine stack of fiber strands with a PEFB fibers size of 3.0 – 5.0 ± 0.05 mm. Then, the PEFB fibers were refined to 0.5 – 1.5 ± 0.05 mm of particle size and were weighted based on the composition ratios using an analytical balance. The epoxy resin and hardener were mixed with a ratio of 3:1 to form a matrix and the mixture was poured into a mold with a 10.0 ± 0.05 mm thickness. Next, the curing time was approximately 48 hours at a room temperature of 25°C. After the curing time, the PEFB/LDPE polymer composites was removed from the mold. Figure 2 shows the different composition ratios of PEFB/LDPE polymer composites.

Table 4: Mechanical and Physical Properties of PEFB fibers

Sample	Ratio of PEFB fiber	Ratio of LDPE plastic waste	Ratio of epoxy resin and hardener
A	0.1	0.2	3:1
B	0.2	0.2	3:1
C	0.3	0.2	3:1
D	0.4	0.2	3:1
E	0.5	0.2	3:1

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 7 Issue 22 (September 2025) PP. 169-178
DOI 10.35631/IJIREV.722012

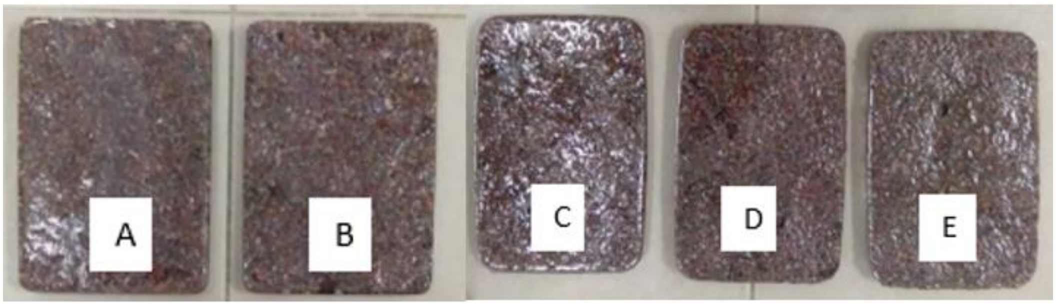

Figure 2: The Different Composition Ratio of PEFB/LDPE Polymer Composites Sample (A) 0.1, (B) 0.2, (C) 0.3, (D) 0.4, (E) 0.5 (wt/wt%)

Results and Discussions

Density and Porosity Analysis

The result revealed that the density decreased as the PEFB fibers ratios increased, as shown in Figure 3. The lowest density was 1.048g/cm^3 at the highest PEFB fibers ratio of 0.5 (wt/wt%), while the highest density was 1.234 g/cm^3 at the lowest PEFB ratio of 0.1 (wt/wt%). A previous study on the characteristics of PEFB composites board reported a density and porosity test as a water absorption test. The greater the amount of resin in a material mixture, the less water absorption into the sample. Thus, the higher the resin applied, the lesser the pores observed (Nayyab, 2024). Therefore, the presence of PEFB fibers as fillers in the matrix reduces the sample density and makes it lightweight.

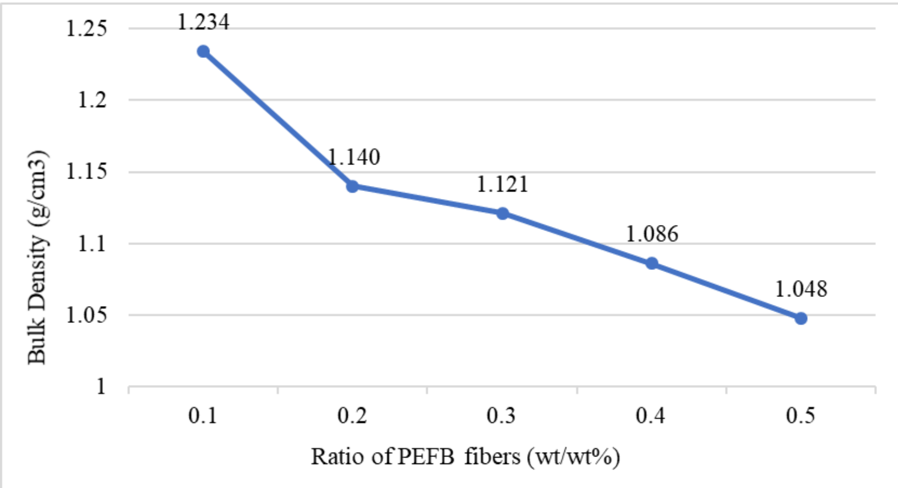

Figure 3: Density With Different Ratio of PEFB Fibers Reinforced LDPE Plastic Waste into Polymer Composites for Deck Panel Application

Figure 4 shows that the porosity of all samples was in an ascending trend as the ratio of PEFB fibers increased from 0.1, 0.2, 0.3, 0.4, and 0.5 (wt/wt%). The lowest apparent porosity is 53.0% at the lowest ratio 0.1 (wt/wt%) and a 0.5 (wt/wt%) of PEFB fibers resulting in the higher percentage of porosity apparent of 60.0%. Therefore, the study revealed that the higher the amount of PEFB fibers, the greater the appearance of the porosity in the polymer composites. A result from previous revealed that higher surface density leads to a denser fibrous network with a low porosity rate, and longer fiber reduces the total amount of fibers while increasing pore size (Ichim, 2024).

International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972
IJIREV
Volume 7 Issue 22 (September 2025) PP. 169-178
DOI 10.35631/IJIREV.722012

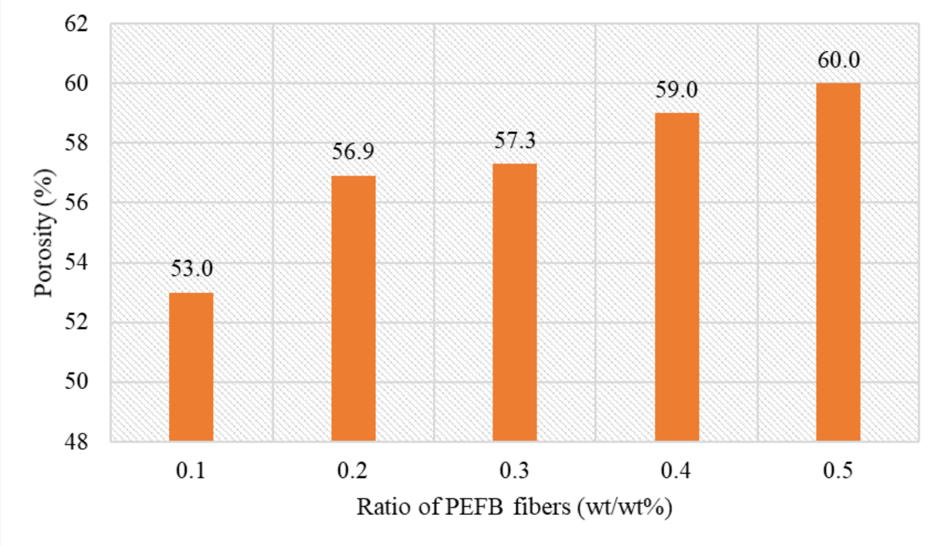

Figure 4: The Percentages of Apparent Porosity in Polymer Composites Sample

Tensile Strength Analysis

The tensile strength grew that as the weight of the filler grew due to a filler matrix bonding that is stronger than most composites with less filler strength, a medium quantity of filler loading provides the maximum tensile strength. A previous study on coir fiber reinforced polyester composites revealed that optimal composite strength required a substantially higher number of fibers in a sample than the epoxy sample (Jamal, 2024). It is highlighted that a larger fiber aspect ratio can transmit the load more efficiently. Figure 5 shows that Sample D with a ratio 0.4 (wt/wt%) had the highest tensile stress of 6.20 MPa, the highest load value of 360.89 N at a peak elongation of 2.84 mm. Where, the lowest tensile strength at a 0.1 (wt/wt%) ratio of PEFB fibers, which tolerates the lowest load value of 123.96 N with a tensile stress of 1.80 MPa and had elongate to 2.06 mm at peak. Since epoxy is brittle, which reduces its ability to absorb impact energy. Therefore, a filler matrix bonding that is stronger than most composites with less filler strength, a medium quantity of filler loading provides the maximum tensile strength (Shah, 2020).

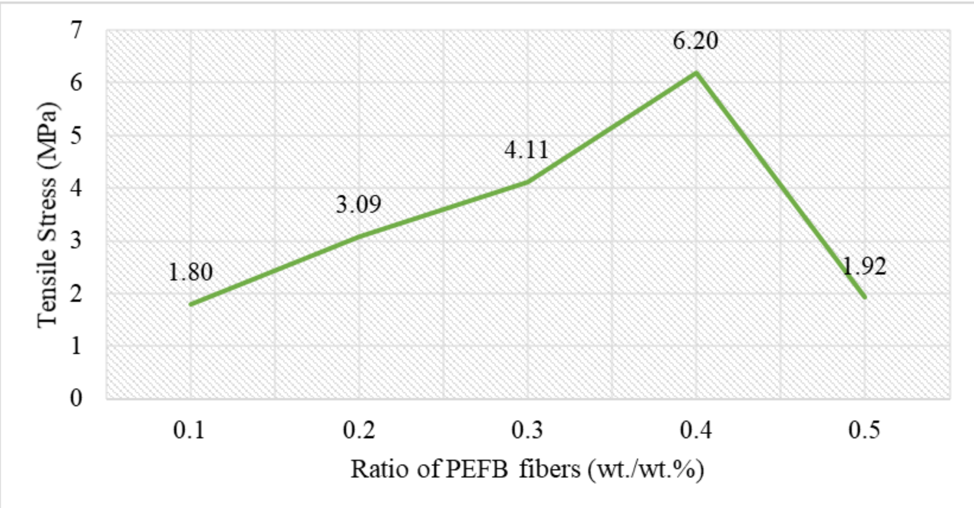

Figure 5: Tensile Strength with Different Ratio of PEFB Fibers

Volume 7 Issue 22 (September 2025) PP. 169-178
DOI 10.35631/IJIREV.722012

Young's Modulus Analysis

The result shows that 0.4 wt/wt% of PEFB gives the higher the tensile of materials, the higher the young's modulus of materials. Elastic modulus measures a material's resistance to tensile load as the corresponding stress-strain relationship expects the material's stiffness (Rajakumar, 2022). It is sufficient to prove the tensile strength and young's modulus rise when the composite material stiffens (Serra-Parareda, 2021). That is, it can withstand more load and so deforms less. As a result, a material or structure with a significant volume and a low modulus of elasticity has a high impact strength because stresses must be transmitted uniformly throughout the object. Figure 6 shows the young's modulus (N/mm^2) for different composition ratios of PEFB/LDPE polymer composites samples, where ratio of 0.4 (wt/wt%) has 2.83 N/mm^2 of Young's modulus.

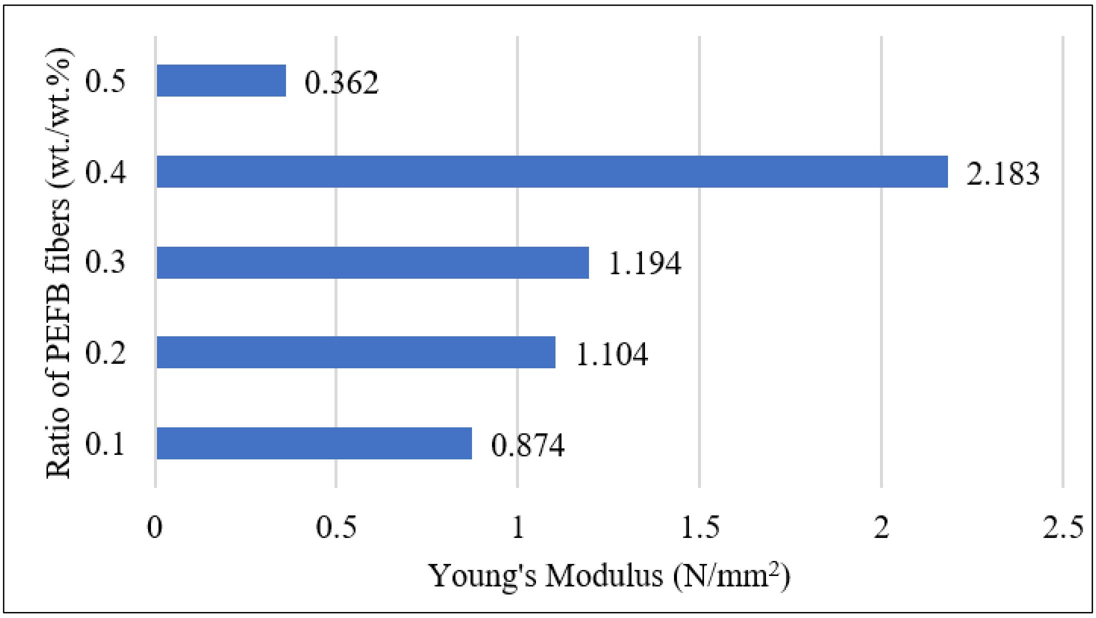

Figure 6: Young's Modulus with Different Ratio of PEFB fibers

Acknowledgements

The authors are grateful for the fruitful discussions and input UTHM staff brought to the project. This research was supported by Ministry of Higher Education (MOHE) through Fundamental Research Grant Scheme (FRGS) (FRGS/1/2022/TK02/UTHM/03/4). We also want to thank to the Government of Malaysia which provide MyBrain15 programme for sponsoring this work under the self-funded grant and L00022 from Ministry of Science, Technology and Innovation (MOSTI). The authors also acknowledge the Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia (UTHM), and Myflexitank Industries Sdn Bhd and Angkasa Kowaris Plastics Sdn Bhd for the equipment and technical assistance. The authors are grateful for the fruitful discussions and input UTHM staff brought to the project.

Volume 7 Issue 22 (September 2025) PP. 169-178
DOI 10.35631/IJIREV.722012

References

Abdullah, R. H., and Essa, A. F. (2021). Measuring the Peeling Strength between Polymers (Low Density Polyethylene, Ethylene Propylene Diene Monomer (EPDM) rubber) and Brass and Evaluating the Effect of Thermal and Chemical Oxidation on the Metal. *Materialstoday: proceedings*, 47(17), 5992-5998.

Achmad, Z., Ismail, A. E., and Hamdan, A. (2021). The Effect of a Mixture of Epoxy Resin Matrix Composite Materials and Hardener by Varying the Stirring Speed on The Mechanical Properties. *International Journal of Engineering Trends and Technology*, 69(11), 83-88.

Faizi, M. K., Shahriman, A. B., Abdul Majid, M. S., Abdul Rahman, M. N. M., Shamsul, B. M. T., Ng, Y. G., Razlan, Z. M., Wan, W. K., Hashim, M. S. M. and Rojan, M. A. (2019). The physical properties observation of oil palm empty fruit bunch (OPEFB) chemical treated fibres. *IOP Conference Series: Materials Science and Engineering*, 670, 1-4.

Ghazalli, S.A., Selamat, H., Khamis, N. and Haniff, M. F. (2023). Short Review on Palm Oil Fresh Fruit Bunches Ripeness and Classification Technique. *Journal of Advanced Research in Applied Mechanics*, 106(1), 37-47.

Ichim, M., Muresan, E. I. and Codau, E. (2024). Natural-Fiber-Reinforced Polymer Composites for Furniture Applications. *Polymers*, 16(22), 3113-3122.

Jamal, I.I., Marsi, N., Letchumanan, T., Rus, A.Z.M., and Hashim, M. M. (2024). Characteristics of Mechanical Strength of Hybrid Reinforced Plastic Waste Mixed with Wood Waste. *International Journal of Automotive and Mechanical Engineering*, 21(2), 11276-11286.

Jamal, I. I., Marsi, N., Rus, A.Z.M., Bahri, A. H. S., Md-Said, A., Hashim, M. M., and Ariffin, I. A. (2024). Mechanical Characteristics Rice Husk Fiber (RHF) Blended Recycled Polyethylene (RPE) for RHF/RPE Polymer Composite. *Journal of Advanced Research in Applied Mechanics*, 118 (1), 144-156.

Kaewtrakulchai, N., Wisetsai, A., Phongaksorn, M., Thipydet, C., Jongsomjit, B., Laosiripojana, N., Worasuwannarak, N., Pimsamarn, J., and Jadsadajerm, S. (2024). Parametric Study on Mechanical-Press Torrefaction of Palm Oil Empty Fruit Bunch for Production of Biochar. *Carbon Resources Conversion*, 1, 1-11.

Kormin, S., Kormin, F., Beg, M.D.H., and Piah, M. B. M. (2017). Physical and Mechanical Properties of LDPE Incorporated with Different Starch Sources. *IOP Conference Series: Materials Science and Engineering*, 226, 1-9.

Krehula, L.K., Persic, A., Popov, N., and Krehula, S. (2024). Polymer Composites of Low-Density Polyethylene (LDPE) with Elongated Hematite (α-Fe2O3) Particles of Different Shapes. *Journal Composites Science*, 8(2), 73-85.

Lu, S.J., Yang, T., Xiao, X., Zhu, X.Y., Wang, J., Zang, P.Y. and Liu, J.A. (2022). Mechanical Properties of the Epoxy Resin Composites Modified by Nanofiller under Different Aging Conditions. *Journal of Nanomaterials*, 2022(1), 1-22.

Markandan, K., and Lai, C. Q. (2023). Fabrication, properties and applications of polymer composites additively manufactured with filler alignment control: A review. *Composites Part B: Engineering*, 256, 1-22.

Nayyab, G. E., Zakaria, M.R.S., Abid, M., Shamim, A., Suradi, A. S., Marsi, N. and Kormin, F. (2024). A Review on Biodegradable Composite Films Containing Organic Material as a Natural Filler. *Journal of Inorganic and Organometallic Polymers and Materials*, 1-20.

International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972
IJIREV
Volume 7 Issue 22 (September 2025) PP. 169-178
DOI 10.35631/IJIREV.722012

Ojo, A. O. (2023). An Overview of Lignocellulose and Its Biotechnological Importance in High-Value Product Production. *Fermentation*, 9(11), 990-1005.

Parveez, G. K. A., Leow, S., Kamil, N.N., Madihah, A.Z., Ithnin, M., Ng, M.H., Yusof, Y.A., and Idris, Z. (2024). Oil Palm Economic Performance in Malaysia and R&D Progress in 2023. *Journal of Oil Palm Research*, 36(2), 171–186.

Pilapitiya, P.G.C.N.T. (2024). The World of Plastic Waste: A Review. *Cleaner Materials*, 11, 1-23.

Phiri, R., Rangappa, S. M., Siengchin, S., Oladijo, O. P., and Ozbakkaloglu, T. (2024). Advances in Lightweight Composite Structures and Manufacturing Technologies: A Comprehensive Review. *Heliyon*, 10(21), 1-24.

Rajakumar, I. P. T., Raguraman, D., Samson, Isaac, J., Suthan, R., Bhattacharya, S., Seikh, A. H., Khan, S. M. A., and Raghavan, I. K. (2022). Mechanical Properties of Polymer Composites Reinforced with Alkaline-Treated Natural Fibre. *Advanced in Polymer Technology*, 2022(1), 1-12.

Serra-Parareda, F., Vilaseca, F., Aguodo, R., Espinach, F.X., Tarres, Q. and Delgado-Aguilar, M. (2021). Effective Young’s Modulus Estimation of Natural Fibers through Micromechanical Models: The Case of Henequen Fibers Reinforced-PP Composites. *Polymers*, 13(22), 3947, 3958.

Shah, S.S.M., Munirah, N. R., and Noriman, N.Z. (2020). The influences of filler loading on tensile properties and waterabsorption properties of carbonized sugarcane bagasse filled high density polyethylene (HDPE) composite. *IOP Conference Series: Materials Science and Engineering*, 932(2020), 1-8.

Thanikodi, S., Meena, M., Dwivedi, Y. D., Aravind, T., Giri, J., Samdani, M. S., Kansal, L., Shahazad, M., and Ilyas, M. (2024). Optimizing the Selection of Natural Fibre Reinforcement and Polymer Matrix for Plastic Composite using LS-SVM Technique. *Heliyon*, 10(21), 1-24.