CHARACTERIZATION OF OIL PALM EMPTY FRUIT BUNCHES FIBER MIXED LOW-DENSITY POLYETHYLENE (PEFB-LDPE) POLYMER COMPOSITES FOR DECK PANEL

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DEDICATION

This thesis is dedicated to people who have supported me consistently throughout my life.

To whom I am grateful to

To my cherished family,

To my cherished supervisor

To my closest friends

I appreciate you so much for being there for me when I needed you the most.

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ABSTRACT

Currently, Malaysia relies heavily on landfills with approximately 85% of waste collected ending up in dumpsites, especially oil palm biomass and plastic waste. Malaysia is one of the largest producers of oil palm. The huge production of palm oil generates oil palm biomass has resulted in a significant waste disposal problem. The major dumping issue results have given the presence of the volume of palm oil biomass of Palm Empty Fruit Bunches (PEFB). Therefore, to solve this issue regarding waste, the waste from the by-product of PEFB and LDPE can be promoted as the infill material in polymer composites. The preparation of the samples involved the grinding process of PEFB fiber of different ratios with 0.1, 0.2, 0.3, 0.4, 0.5, and 0.6 into a small particle size of 1.3 – 1.5 mm. The PEFB-LDPE polymer composites were transferred to a 200 mm x 200 mm aluminum using a close-mold method at room temperature (24ºC ± 2ºC) for 24 hours for the curing process. The PEFB-LDPE ratio of 0.3 achieved a density of 1.0677 g/cm^3 and average porosity of 12.8%. The SEM image 0.3 PEFB-LDPE demonstrates fewer pores and better fibers and epoxy resin matrix dispersion. Lower pores in 0.3 PEFB-LDPE samples indicate the higher mechanical strength of the composite. The tensile strength test (ASTM D3039) showed that the ratio of 0.3 PEFB-LDPE achieved the highest tensile strength at 18.18 MPa with a strain percentage of 3.28%. It is like a flexural strength test (ASTM D7264), the ratio of 0.3 PEFB-LDPE revealed the highest value at 26.20 MPa with the impact energy of (ASTM D7136) at 159.89 J/m and energy absorbed at 10.10 kJ/m^2. For the compression strength test (ASTM D95), the ratio of 0.3 PEFB-LDPE produces a higher value at 12.59 MPa. In terms of sound absorption (ASTM E1050), the PEFB-LDPE ratio of 0.3 was 0.50 at a frequency of 1250 Hz, but the α increased to 0.59 at a frequency of 2000 Hz. The material is considered sound absorbent if the average sound absorption coefficient is greater than 0.2 after all the five major frequencies have been calculated. In conclusion, the ratio of 0.3 PEFB-LDPE was good mechanical properties of tensile, flexural, impact strength, and sound absorption compared to the commercial polymer composite of kenaf bast and kenaf core in fabricating the deck panel applications.

ABSTRAK

Pada masa ini, Malaysia sangat bergantung kepada tapak pelupusan sampah dengan kira-kira 85% sisa yang dikutip berakhir di tapak pelupusan, terutamanya biojisim kelapa sawit dan sisa plastik. Pengeluaran minyak sawit menjana biojisim kelapa sawit telah mengakibatkan masalah pelupusan sisa yang ketara. Objektif utama kajian ini adalah untuk menentukan nisbah gentian PEFB yang dicampurkan ke dalam LDPE untuk menghasilkan komposit polimer PEFB-LDPE. Penyediaan sampel melibatkan proses pengisaran gentian PEFB dengan nisbah berbeza dengan 0.1, 0.2, 0.3, 0.4, 0.5, dan 0.6 kepada saiz kecil, iaitu 1.3 – 1.5 mm. Komposit polimer PEFB-LDPE dipindahkan ke dalam acuan aluminium 200 mm x 200 mm menggunakan kaedah acuan bertutup pada suhu bilik (24ºC ± 2ºC) selama 24 jam untuk proses pengawetan. Sampel komposit polimer PEFB-LDPE telah diuji pada sifat fizikal dan mekanikalnya. Nisbah PEFB-LDPE 0.3 mencapai ketumpatan kedua terendah 1.0677 g/cm^3 dan keliangan purata 12.8%. Imej SEM 0.3 PEFB-LDPE menunjukkan sedikit liang dan menjadi gentian yang lebih baik dari segi penyebaran matriks resin epoksi. Liang yang lebih rendah dalam sampel PEFB-LDPE 0.3 menunjukkan kekuatan mekanikal komposit yang lebih tinggi. Ujian kekuatan tegangan (ASTM D3039) menunjukkan nisbah 0.3 PEFB-LDPE mencapai kekuatan tegangan tertinggi pada 18.18 MPa dengan peratusan terikan sebanyak 3.28%. Bagi ujian kekuatan lentur (ASTM D7264), nisbah 0.3 PEFB-LDPE menunjukkan nilai tertinggi pada 26.20 MPa dengan tenaga hentaman (ASTM D7136) pada 159.89 kJ/m dan tenaga yang diserap pada 10.10 kJ/m^2. Bagi ujian kekuatan mampatan (ASTM D95), nisbah 0.3 PEFB-LDPE menghasilkan nilai yang lebih tinggi pada 12.59 MPa. Dari segi penyerapan bunyi (ASTM E1050), nisbah PEFB-LDPE 0.3 ialah 0.50 pada frekuensi 1250 Hz, tetapi α meningkat kepada 0.59 pada frekuensi 2000 Hz. Bahan tersebut dianggap penyerap bunyi jika purata penyerapan bunyi lebih besar daripada 0.2 selepas kesemua lima frekuensi utama dikira. Kesimpulannya, nisbah 0.3 PEFB-LDPE mempunyai sifat mekanikal yang baik bagi kekuatan tegangan, lenturan, hentaman dan penyerapan bunyi berbanding komposit polimer komersial yang di campur kulit kenaf dan teras kenaf dalam fabrikasi aplikasi panel dek.

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LIST OF SYMBOLS AND ABBREVIATIONS

%	-	Percentage
ASTM	-	American Society for Testing and Machine
C	-	Atom
℃	-	Degree Celsius
CC	-	Ceramic Composite
cm	-	Centimeter
cm^3		Cubic Centimetre
db	-	Decibel
g	-	Gram
HDPE	-	High-Density Polyethylene
HDT	-	Heat Deformation Time
Hz	-	Hertz
J	-	Joule
kV	-	Kilo Volt
kW	-	Kilowatt
LDPE	-	Low Density Polyethylene
m	-	Meter
MAgPP	-	Maleic Anhydride graft Polypropylene
MC	-	Metal Composite
min	-	Minute
mm	-	Millimeter
MPa	-	Mega Pascal
MSW	-	Municipal solid waste

MSWPC-PEFB	-	Municipal solid waste mixed polymer composite-based Palm Empty Fruit Bunches
O^2	-	Oxygen
PC	-	Polymer Composite
PCM	-	Polymer Composite Material
PEFB	-	Palm Empty Fruit Bunches
PEFB-LDPE	-	Palm Empty Fruit Bunches-Low Density Polyethylene
PET	-	Polyethlene Terepthalate
PP	-	Polypropylene
PVC	-	Polyvinyl Chloride
RIM	-	Reaction Injection Molding
Rpm	-	Revolutions per minute
SAC	-	Sound absorption coefficient
SEM	-	Scanning Electron Microscope

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CHAPTER 1

INTRODUCTION

In recent years, there has been an increasing interest in seeking fiber solutions for effective and inexpensive. Amongst the many potential ways is to use natural fiber to form composites of polymers due to their environmentally sustainable and reusable existence (Padzil, 2020). Natural fiber has many advantages, including low density, low cost, biodegradability, acceptable specified properties, improved thermal and insulating properties, and low energy in manufacturing (Maya, 2021).

Basically, the natural fiber in polymer composites that have been highly investigated is jute, kenaf, cotton, flax, and hemp. These natural fibers are widely used to provide better performances of tensile strength, flexural strength, stiffness, and elongation to break with a binder matrix (Karimah, 2021). Therefore, it is practical to consider biomass waste from different sources to produce by-products because of its capability to be transformed from waste into useful energy and products. The potential role of the use of natural fibers help to produce products that are recyclable and biodegradable (Thyavihalli, 2019). Managing waste of creating wealth from waste is necessary for supporting the environment and impact on nature. Researchers are finding ways to increase the capacity of products based on waste resources to replace imitation resources as a green alternative.

Malaysia is one of the world's largest oil palm producers and experiences robust growth through giant government-owned companies Federal Land Development Authority (FELDA), Federal Land Consolidation and Rehabilitation Authority (FELCRA), and Rubber Industries Smallholder Development Authority (RISDA), and private estates such as Sime Darby Plantation, IOI Plantation, Genting Plantation, and many others in new plantations and palm oil mills (Jenny, 2019). However, there is an abundance of waste material available from the palm tree consisting of around 90% of biomass waste and only around 10% of oil. Biomass waste produced from the oil palm industries such as oil palm trunks (OPT), oil palm frond (OPF), palm empty fruit bunches (PEFB), palm pressed fibers (PPF), palm shells, and palm oil mill effluent palm (POME) (Jafri, 2021). PEFB is one of the highest biomass waste productions. This abundance of PEFB from the biomass waste is a natural source of fiber and can be used in the polymer composite as potential reinforcement material (Faizi, 2017). Plastic reinforced with natural fibers provides the best alternative and it may revolutionize the entire world during this century (Thyavihalli 2019).

Plastic is one of the Municipal Solid Waste (MSW) components, including polyethylene terephthalate (PET), high-density polyethylene (HDPE), polyvinyl chloride (PVC), low-density polyethylene (LDPE), polypropylene (PP) and polystyrene (PS). Thermoplastic polymers are examples of typically used binder matrices which are LDPE, PP, PVC, PS polyethylene (PE), and polyurethane (PU). Meanwhile, thermoset polymers include phenolics, epoxies, isocyanates, and unsaturated polyesters (Wu, 2019). In the case of thermoplastic polymers, recycling and incineration process are usual elements of the recovery method (Subham, 2021). However, there are some problems with incineration, such as the production of toxic gases and the residues of ash that contained lead and cadmium. Therefore, recycling and composting are almost the best way to get rid of waste management.

There are benefits to recycling, such as reducing environmental issues and saving both material and energy (Wu, 2019). The preparation of polymer composites from recycled thermoplastic with natural fibers is an attractive alternative that gives to the preservation of natural resources, decreases pollution waste, and production of low-cost materials. These materials, such as other types of waste, can be converted into high-demand bio-based products, particularly in the fields of bioenergy, bio-agriculture, eco-products, and bio-chemicals (Subham, 2019). LDPE is also the largest amount of waste with up to 40 million tonnes annually (Chamas, 2020) and waste material available from the palm tree consists of around 90% of biomass waste. Therefore, this study intended to use palm empty fruit bunches fiber (PEFB) and LDPE one types of abundance waste materials and biomass waste products to characterize the physical and mechanical properties to produce PEFB-LDPE polymer composites for deck panels.

1.1 Research Background

The oil palm from Malaysia is most significant in changing the agriculture and economic scenario. Lignocellulosic biomass derived from the oil palm industry includes oil palm trunks (OPT), oil palm fronds (OPF), palm empty fruit bunches (PEFB), palm pressed fibre (PPF), palm shells and palm oil mill effluent palm (POME). However, the presence of such biomass palm waste has created a significant disposal challenge (Jafri, 2019).

The core principles of waste management are to reduce and recycle the waste, recover resources and eventually dispose the waste. These principals refer to agro-industrial wastes, such as palm oil residues as MSW and no longer enable the dumping of residues where there is an economically useful alternative. Researchers need to consider the existing uses and disposal of mill residues to resolve the potential for energy recovery in the palm oil industry to solve the issue (Kaniapan, 2021). One of the unique features of Malaysian renewable energy sources is that the palm oil mill is energy self-sufficient, using empty palm fruit bunches (EFB), and shell as fuel to generate steam for processing in waste-fuel boilers and steam turbines power generation for the industrial sector (Obuka, 2018). Industrial growth continues with physical materials and sustainability for commodity manufacturing. Furthermore, technical methods require a variety of innovative materials that can be extended, which have a long-term market opportunity. Without materials, there will be no food and shelter technology, there might be no work, and thus no economic development (Moser, 2019).

Renewable resource is necessary to fulfil energy requirement. Oil palm waste is a reliable resource due to its green energy, availability, continuity and capacity for renewable energy solution. The palm tree consists of about 90% of biomass waste and 10% oil. In 2020, approximately 90 million tonnes of oil palm fruits were produced and 43%–45% of this was mill residues in the form of PEFB, shell and fibre (Kaniapan, 2021). In addition, the presence of oil palm biomass waste of PEFB in the current scenario produces a severe waste disposal problem, and thereby impacts the environment. In order to meet the best possible solution of oil palm biomass waste of PEFB, the technical, economical, energy balance and environmental requirements should be balanced (Hasan, 2020).

The same issue with plastic waste, LDPE plastic waste from packaging film also poses a low index mechanical recycling index that causes numerous environmental problems and is used after discarding for its maintenance (Jafri, 2019). More than one billion LDPE plastic waste ended up in Malaysian landfills since 2003, according to Performance Management and Delivery Unit Malaysia (PEMANDU, 2015). Plastics are generally not biodegradable and can endure for long periods time. To help decreasing environmental pollution, reducing waste and creating a cleaner world, there are practical benefits to researchers for trying to recycle LDPE plastic waste (Narinder, 2016). The growing production of LDPE plastic waste on a global scale is startling. This exponential increase in plastic production is due to the plastic revolution in which chemists are developing new methods to expand the limits of polymers (Chen, 2019).

However, plastic products are starting to be targeted by new environmental legislation. By melting or burning, LDPE plastic waste may be removed, but this results in other issues, such as toxic fumes and a contribution to global warming. LDPE plastic waste incineration will have a detrimental effect towards the environment, such as air pollution that emissions into the atmosphere, and the generation of polluted waste water and ashes in the air (Bukhari, 2022). New alternative approaches to recycle LDPE plastic waste includes blending the mixing of virgin polymer with recycled material. Usage of additives is to strengthen the formulations, whereby natural fibre polymer reinforcing experiments are suitable to create polymer composites with superior mechanical properties. Sustainable development can also be encouraged by long term promotion of bio-products from polymer composite project with the use of local expertise and the creation of employment (Mohanti, 2019).

LDPE plastic waste as a filler can be implemented with reinforcement of polymers with natural fibre to produce polymer composite material in the fabrication of deck panel applications (Rajak, 2019). This is the safest way to dispose of the abundantly usable LDPE plastic waste and reduce the amount of incineration. The preparation of polymer composites from recycled thermoplastic, such as LDPE plastic waste reinforced by natural fibre like PEFB, is an interesting alternative that contribute to the preservation of natural resources, decrease of pollutant waste, production of low-cost materials, green environment and sustainable technology (Kaniapan, 2021).

Due to its mechanical and physical properties, PEFB fibre and LDPE plastic waste are ideal for producing the polymer composite as a reinforcing material in the deck panel applications. The study on polymer composites has increased, because the number of technology advantages does not require high temperatures, long periods of time and complex manufacturing processes (Kamrun, 2019). It can be transformational behaviour without failure to the reinforcement material at low temperature and produces high durability of polymer composites. The deck panel is commonly used for building purposes. Deck panel is a non-load bearing interior wall mounted in a wall for decorative and division purposes.

Prefabricated office wall partition systems that simulated stick-built walls were available before the modern cubicle became popular in the 1960s (Mike, 2017). Recently, the building markets have shown signs that lightweight deck panel solutions, such as drywalls, ceiling panel, deck stairs, garden chair, gate panelling and outdoor decking are used routinely. This research utilised PEFB fibre mixed LDPE plastic waste to produce PEFB polymer composite as the main raw material for the production of deck panel. The presence of PEFB fibre in the polymer matrix has potential and advantages in sustainability with the use of raw materials from MSW. It offers the possibility of improving the physical and mechanical properties and developing sustainable materials used.

1.2 Problem Statement

One of the main problems experienced by the Department of Environment Malaysia is determining the best way to dispose of MSW, particularly the garden waste of PEFB and plastic waste of LDPE. In 2020, more than 20 million tonnes of PEFB waste production was placed as the world's second-largest producer in 2019 (MPOB, 2019).

PEFB is considered the lowest cost of natural fibre with suitable properties and exists abundantly in Malaysia (Faizi, 2017). It has excellent potential as an alternative primary raw material to substitute synthetic fibre. Meanwhile, LDPE plastic worldwide annual production reached 300 million tonnes, however, worldwide plastic recycling contributed to only 10% of this production. The plastic recycling and incineration process are the usual aspects of recovery methods in thermoplastic polymers (Elena, 2017). The incineration presents some problems like toxic gases and residue ash, which contains lead and cadmium (Elena, 2017). The recycling offers advantages, such as reduction of environmental issues and saving both material and energy. It should benefit LDPE plastic waste to be implemented into recycled materials through grinding or shredding to reinforce polymers with natural fibre to produce composite material, such as deck panels (Mohammed, 2015).

The deck panel from composite materials is an ideal candidate to replace conventional materials, such as wood and concrete. However, it has several weaknesses, such as low durability, and the loss of density only slightly influencing heavy weight and mechanical performance of the compression and bending strength (Rajak, 2019). The need for high quality locally made material deck panel is in higher demand due to the out of reach costly imported deck panels. Therefore, a new bio-product of composite deck panels made from PEFB fibre and LDPE plastic waste will be determined in this study. Many researchers worldwide had studied polymer composite as reinforced materials for waste, including plastic, glass, wood, and paper as reinforced materials (Kamrun, 2019).

However, studies on the utilization of PEFB fibre and LDPE plastic waste in composite materials are limited because most researchers are focused on fibre only rather than reinforced or combined two or more types of waste. PEFB fibre is the main natural fibre in composite materials that possess better mechanical properties, such as high tensile strength, high flexural strength, superior impact properties, and soundproof properties (Mohammed, 2015). Using polymerization formulation, epoxy resin will be converted from liquid to solid-state in a cross-linked molecular structure to form polymer composites, whereas previously, synthetic resins contained celluloid, melamine, and bakelite (Keya, 2019). These renewable polymer composite materials are expected to improve performance than other synthetic composite materials (Das, 2018). Nevertheless, LDPE plastic waste alone could not have enough strength and rigidity for structural applications. To increase the system’s strength and rigidity, it is necessary to provide further reinforcement.

The proposed materials in this study, PEFB fibre, and LDPE plastic waste help to improve the PEFB polymer composite’s performance. Traditionally, deck panel is made from conventional materials, such as concrete, wood, and gypsum. The conventional deck panels are heavy and will increase the installation time. The proposed reinforced materials from PEFB fibre and LDPE plastic waste were less dense than concrete, wood, and gypsum (Martin, 2012). Therefore, PEFB polymer composites are easy and fast to install and require fewer workers than conventional deck panel installation. Utilization of fibre and plastic waste in the polymer composite will reduce the composite panel density, and have higher strength and higher acoustic performance compared with the conventional deck panels that are heavier, highly brittle and lower durability (Chauhan, 2019).

Therefore, the utilisation of PEFB polymer composite in a deck panel application can be potentially made. The use of PEFB and LDPE waste can reduce pollution problems and increase use-value bio-products. This study utilises PEFB fibre mixed LDPE plastic waste to produce PEFB polymer composite, as the main raw material for the deck panel fabrication. The addition of PEFB fibre as filler in the polymer matrix may provide potential advantages in sustainability by raw materials from MSW. It offers the possibility of improving the mechanical properties and developing suitable materials used. Characterization of PEFB-LDPE polymer composites for deck panels is an alternative on reducing environmental problems to support eco-green products, minimize pollution and enhancing environmental sustainability. Utilizing oil palm biomass waste to create a useful composite is a prudent use of resources that also supports a greener environment.

1.3 Research Objectives

The main objectives of this research are as follows:

(a) To prepare the composition ratio of PEFB fibre mixed LDPE to produce PEFB-LDPE polymer composites and evaluate the physical properties and mechanical properties based on different composition ratio

(b) To compare the mechanical performance of optimum composition PEFB-LDPE polymer composite with other polymer composites for deck panel application.

1.4 Research Scope

This study focuses on evaluation of characterisation of PEFB-LDPE polymer composites for deck panel. PEFB fibre was used as the main waste material in reinforcing the composite materials. The LDPE was provided from Kedah by MY Flexitank Industries Sdn. Bhd. The type of epoxy resin used was DER 324 Liquid

Resin from DOW Company and the hardener was Jointmine 905-3s from SUKA Company, Shah Alam. The study’s scope are as follows.

(a) To determine the composition ratio of PEFB fibre mixed LDPE to produce PEFB-LDPE polymer composites and evaluate the physical properties and mechanical properties based on different composition ratio of PEFB fibre mixed LDPE to produce PEFB-LDPE polymer composites, as shown in Table 1.2 and Table 1.3.

Seven different composition ratio have been determined in Table 1.1, including the control sample and constant ratio of epoxy resin and hardener for mixing purposes. This study used a manual mixing process by using stir and hand lay-up method for laying the mixture into a 200 mm x 200 mm mould for curing process at room temperature (24ºC ± 2ºC) for 24 h. Hardened PEFB-LDPE polymer composite samples were cut using Sawyer Circular Band Saw with specific dimensions, depending on the physical testing and mechanical testing specimen sizes. The composition ratios are referring previous researcher, Mao (2019).

Table 1.1: The different composition ratios of PEFB-LDPE Polymer composites

PEFB-LDPE	**Ratio of PEFB fibre**	**Ratio of LDPE plastic waste**	**Epoxy Resin**	**Ratio of Hardener**
A	0.0	0.2	3	1
B	0.1	0.2	3	1
C	0.2	0.2	3	1
D	0.3	0.2	3	1
E	0.4	0.2	3	1
F	0.5	0.2	3	1

Table 1.2: Physical test for PEFB-LDPE polymer composites

No.	Testing	Standard	Specimens
1	Density and Porosity Test	ASTM D792 - 13 (Standard Test Methods for Density and Specific Gravity (Relative Density of Plastics by Displacement)	3 specimens for each ratio. Total specimens were 21.
2	Scanning Electron Microscope (SEM) Analysis and Energy Dispersive X-Ray (EDX) Analysis	ASTM E766-14e1 (Standard Practice for Calibrating the Magnification of a Scanning Electron Microscope)	- 1 specimen for each ratio. Total specimens were 7. - Fractured sample from tensile strength test to analyse the cross-section image.

Table 1.3: Mechanical test for PEFB-LDPE polymer composites

No.	Testing	Standard	Specimens	Dimensions
1	Tensile Strength Test	ASTM D3039 (Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials)	3 specimens for each ratio. Total specimens were 21.	25 mm width, 250 mm length and 4 mm thickness.
2	Flexural Strength Test	ASTM D7264 (Standard Test Method for Flexural Properties of Polymer Matrix Composite Materials)		13 mm width, 150 mm length and 4 mm thickness.
3	Impact Strength Test	ASTM-D7136 (Standard Test Method for Measuring the Damage Resistance of a Fibre-Reinforced Polymer Matrix Composite to a Drop-Weight Impact Event)	3 specimens for each ratio. Total specimens were 21.	150 mm length, 13 mm width and 4 mm thickness. 45º notched at the middle of the sample.
4	Compressive Strength Test	ASTM D95 (Standard Test Method for Compressive Properties of Rigid Plastics)	3 specimens for each ratio. Total specimens were 21.	Cylinder shape with 25 mm diameter and 50 mm length.
5	Sound Absorption Test	ASTM E1050 (Standard Test Method for Impedance and Absorption of Acoustical Materials Using a Tube, Two Microphones and a Digital Frequency Analysis System)	1 specimen for each ratio. Total specimens were 7.	100 mm diameter and 4 mm thickness for lower range frequency. 30 mm diameter and 4 mm thickness for higher range frequency.

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APPENDIX C

List of Publication and Awards

Publication

- Hashim, M. M., Masri, N., Mohd Fodzi, M. H., Mohd Rus, A. Z., Ali, R., & Mohd Jamir, M. R. (2021). A Review: Recycling Types of Municipal Solid Waste (MSW) for Bioproducts Development. (1), pp. 1-18.

- Hashim, M. M., Masri. N, Lechumanan. T, Mohd Rus. A., Z, Mohd Jamir., M. R, Hassan. N. (2021). Characteristic of Bending Strength of Plastic Waste (PW) Reinforced Wood Waste (WW) for Polymer Composites**.** Journal of Southwest Jiaotong University. Scopus.

- Hashim, M. M., Masri, N., Mohd Fodzi, M. H., Mohd Rus, A. Z., Ali, R., & Mohd Jamir, M. R. (2021). Characterization of Wall Partition Bioproducts from Plastic Waste Reinforced Polyurethane Foam Composites. (7), pp. 74-85.

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- Hashim, M., M, Masri. N, Mohd Rus, A., Z, Marhaini Sharom, N., S, Md Said, A. (2021**).** Springer.

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VITA

Mohamad Mohshein bin Hashim, was born in Kedah, Malaysia in 1992. He He graduated from UiTM in bachelor‘s degree in Office System Management 2016. His Final Year Project focused on communication problem between employee in one of College in Kedah. His final year project was done while he is doing his internship in Kolej University Insaniah Kuala Ketil, Kedah. After graduated, he is offered a job by one company named MY Flexitank Industries Sdn. Bhd. Day after day, his working company now interested to collaborate with UTHM under Double Tax Deduction (DTD) scheme which is a good and effective programme by the academic institution such as UTHM to help industries to solve or improve the industries needs by using modern technology and expertise to meet customer expectation. This is how he started his study in Master of Engineering Technology at UTHM. He had published several publication and book chapter with other author. He is also awarded a gold award from The International Research and Symposium and Exposition (RISE) in 2021.