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The Effects of Different Length of Pineapple Leaf Fibre (PALF) on Tensile Properties of Random Oriented Composites

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Abstract: Pineapple, AnanasComosus is one of the most primary tropical plant in Malaysia and abundantly available waste materials produced every yea. Previously, there were many pineapples waste available. To date, the use of fibres that were extracted from the pineapple leaf is still limited due to lack of information, knowledge and facilities available to process the leaf into potential materials in various applications. This present study covered on the tensile properties of PALFs composites reinforced with vinyl ester resin in different length of fibre. The composites were fabricated by using hand lay-up technique with different fibre length of PALF. There were three different type of composites which are short (15 mm), mixed (15-30 mm) and long (30 mm) PALF. Based on the result, the highest tensile strength was achieved by the composites that was prepared using the long PALF which is 25.77 MPa while mixed PALF composites showed the highest in tensile modulus (2.848 GPa). In summary, the usage of PALFs in the fabrication of composites had great potential to reduce the non-renewable materials for real-life application.

Index Terms:Pineapple leaf fibre (PALF), tensile properties, vinyl ester resin.

I. INTRODUCTION

Fibre reinforced polymer composites have been applied in aerospace, automotive, aeronautical, military, marine and other applications since the 1950's, as they exhibithigherendurance, resistant, toughness and strength than one material alone [1-2], [28-29]. Polymer composites are made of thermoset and thermoplastic as its matrix [3-4]. Pineapple leaf, previously known to be non-usable materials from pineapple plants, was abundantly produced every year. Until today, the use of pineapple leaf is still limited due to lack of information and facilities available to process the leaf into potential materials in various applications [5-7], [32]. However recently, the expansion of bio composites has attracted researchers' attention [8] due to their excellent performances over synthetic reinforced composites [9], [30] like glass and carbon composites [31] such as biodegradable, low cost and eco-friendly [10-13]. Pineapple leaf fibres (PALF) was one of the natural fibres that possessed a great mechanical property and can be reinforced in the polymer composites. PALF contains high cellulose as high as 83% that can produce composites at tensile strength and modulus of 748MPa and 36GPa respectively suitable for composite reinforcement [14]. It was found that jute, PALF and glass fibre reinforced epoxy composite showed higher tensile properties compared to the one that reinforced with polyester composites with tensile strength of 68.24MPa for polyester composite and 71.66MPa for epoxy composite [15]. In different study, 12 different varieties of pineapple were subjected to tensile testing. It appeared that the tensile strength and modulus obtained were 629-1309MPa and 37-86GPa respectively which was comparable with glass composites [16]. In order to introduce new composites especially associated with natural fibres, characterization of their mechanical properties is the basic information need to be studied. PALF showed high compatibility and has better chemical composition [6]. The researcher reported that the maximum tensile strength and modulus of PALF composites obtained at 10 mm length of PALF which were 18.16 MPa and 2.56 GPa respectively [17].

Bisaria et al. [18] evaluated that 15 mm length of jute/epoxy composites gave the highest tensile strength and modulus with 42.14 MPa and 0.059 GPa respectively. The increasing in the fibre content from 0% to 30% of short PALF-NBR (nitrile rubber) enhanced their mechanical properties [19]. Adhesion between the fibres and matrix is one of the drawbacks in using natural fibres. Therefore, it is important to study about the surface treatment as well as the characteristics of each natural fibre. The silane treated PALF and kenaf composites gave better tensile properties compared to untreated, alkaline and NAOH treated PALF and kenaf composites with the tensile strength and modulus of 629.90 MPa (PALF), 551.23 MPa (kenaf) and 10.99 GPa (PALF), 19.71 GPa (kenaf) respectively [20]. Threepopnatkul et al. [21] find out that NAOH-treated PALF composites with 20% of fibre content showed the highest tensile strength and modulus that were 70-80 MPa and 1.96 GPa respectively. Oliveira et al. [22] determined that at 30% of fibre content, the tensile properties of alkali-treated PALF composites is at maximum with the tensile strength and modulus of 78.2 MPa and 1.82 GPa respectively compared to raw and silane treated PALF composites.

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Other than that, 30% of fibre content produced the maximum tensile properties of 10% NAOH-treated PALF composite with the tensile strength and modulus of 88.7 MPa and 2.5-3 GPa respectively [23]. The previous research work had led to the present study.

This present research work will discover the effect of fibre length on the tensile properties of PALF reinforced with vinyl ester (VE). The tensile tests were performed to estimate the tensile properties of the composite. The tensile strength and modulus obtained by each different length of PALF will be compared and evaluated.

II. MATERIALS & METHODOLOGY

PALF was used in this research work. The chemical components of PALF used in this study are 82.0% cellulose, 18.8% hemicellulose and 12.7% lignin [24]. PALF used in this study was in the roving form of thin yarn with average thickness of 1 mm. The roving PALF was chopped down into three different lengths of 15 mm, 15-30 mm and 30 mm, labelled as short, mixed and long PALF respectively, using the chopper gun.

MFE-11, a premium standard Bisphenol-A type epoxy vinyl ester resin (VE) purchased from Sino Polymer Co., Ltd as used as matrix resin. Typical physical properties of VE resin are presented in Table 1:

Properties	Value	Test Method
Tensile Strength (MPa)	80-95	ASTM D3039
Tensile Modulus (GPa)	3.3-3.6	
Flexural Strength (MPa)	125-152	ASTM D790
Flexural Modulus (GPa)	3.1-3.6	

Table 1: Mechanical Properties of Vinyl Ester Resin Matrix

The fabrication of PALF composites was done by applying moulding method. According to other studies on the natural composites, the ratio of 30:70 was used for PALF to VE resin composites [25]. Respective amount of PALF and VE, according to the ratio, were mixed in a container until all the PALF was wet with VE resin. They were then poured and distributed evenly into the aluminium mould in a random orientation. The composites were left cured in the room temperature of 24 °C for at least 24 hours. Three different types of random-oriented composites were fabricated using short, long and mix PALF composites.

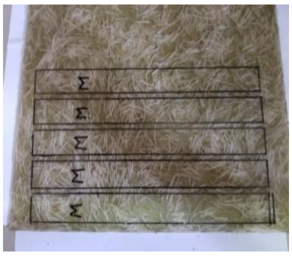

Fig 1. PALF/VE Composites

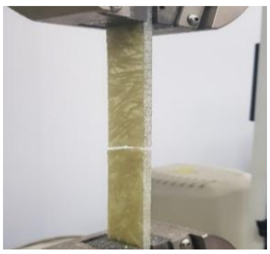

Fig 2. Tensile Testing

The PALF random-oriented composites were evaluated for their mechanical properties. Tensile strength and modulus of the composites were determined in the longitudinal direction in accordance to ASTM D3039 [26]. The sample dimension was 25 mm × 250 mm × 5 mm. The machine used to conduct the tensile test was Universal Tensile Machine (UTM) at a crosshead speed of 1.5 mm per min which is located in Mechanical Laboratory of Mechanical Department of Universiti Putra Malaysia, (UPM). The tensile strength and modulus were evaluated for every sample which were short, mixed and long PALF composite. There were five specimens to be tested for each length of composites.

III. RESULTS & DISCUSSION

Table 2 shows the tensile stress and modulus of three type of samples which were short PALF composites, mixed PALF composites and long PALF composites:

Sample	Tensile Stress (MPa)	Young's Modulus, E (GPa)
Short (15 mm)	25.36	2.588
Mixed (15-30 mm)	25.63	2.848
Long (30 mm)	25.77	2.801

Table 2: Data of Short, Mixed and Long PALF Composite

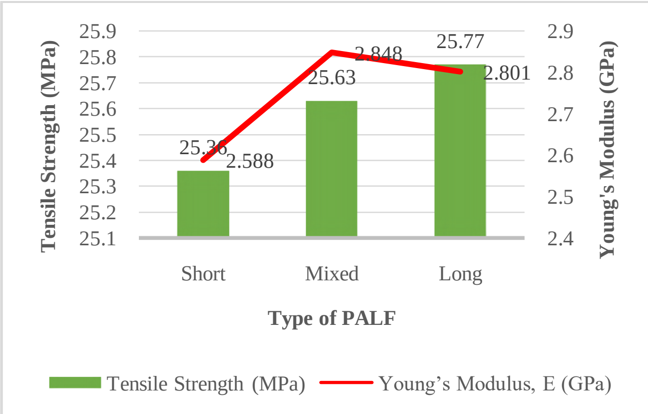

Fig 3. Tensile Properties of Short, Mixed and Long PALF Composites

From the fig 3, we could notice that as the length of the PALF increase, the tensile strength of composite will be increased too and vice versa. From the figure 3, the long PALF/VEcomposites possessed the highest tensile strength amongst the others. The tensile strength increased 1.06% from short to mixed PALF/VE composites. From mixed to long PALF composite, the tensile strength increased 0.55%. The high value of tensile strength showed by long PALF/VE composites indicated that there was a good adhesion bonding and effectively transfer stress between the fibres and matrix. From the previous research, one of the factors that affects the tensile strength value of PALF was its length. The increase the length of fibre, the increase the tensile strength of fibre due to the strong stress transfer between the PALF and VE matrix. It can be concluded that as the length of PALF increase, the tensile strength of PALF composite increase due to the good adhesion and ability to transfer stress between the fibres and matrix effectively [1].

For the Young's modulus of short, mixed and long PALF composite, their values were 2.588 GPa, 2.848 GPa and 2.801 GPa respectively. The

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mixed PALF/VE composites showed the highest tensile modulus compared to other composites. The tensile modulus increased 10.05% from short to mixed PALF/VE composites. From the mixed to long PALF/VE composites, there was a slightly decrease which is about 1.68% in tensile modulus. The increase in fibre length affects the tensile modulus of PALF composite. It could be noticed that the tensile modulus of long PALF/VE composite was lower than mixed PALF/VE composites. This is because if the length of fibres is too long, there is some possibilities for the fibres to be entangled to each other. Thus, the interfacial bonding between the fibres and matrix will be disrupted and led to low tensile modulus. Dagade and Shaikh [17] reported that if the length of fibres is too long, there is some tendencies for the fibres to be entangled to each other that could influence the tensile properties of the composites.

IV. CONCLUSION

In conclusion, the fibre length of PALF affected the performance of fibre-reinforced composites. Based on the results obtained, it can be concluded that the long PALF/VE showed the highest in tensile strength. There was an increased 0.55% from mixed to long PALF/VE composites. The long PALF/VE composites showed the highest tensile strength due to the existence of great adhesion between the fibres and matrix. Great adhesion between the fibres and matrix will increase the tensile strength of composites. Besides, mixed PALF/VE composites showed the highest in tensile modulus due to the effective stress transfer between the fibres and matrix. The fibre length gives a significant effect on the performance of composites [5]. This is most probably due to low microfibrillar angle of 14° and high content of cellulose. Thus, there is an existence of strong bond between the PALF and the VE resin matrix. This is also due to the ability to transfer stress between the PALF and VE resin matrix effectively.

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Ali Ahmad Mazlanobtained his degree in the Aerospace Engineering in the Universiti Putra Malaysia (UPM) in 2018. Currently doing the Master of Science in Aerospace Engineering in the same university. He was awarded as the first runner-up in his Final Year Project (FYP) entitled "Mechanical and Thermal Properties of Pineapple Leaf Fibre (PALF) for the Aerospace Application. He is also one of the authors of "Engineers for Future". He is currently doing the research work on the hybridization of PALF with kenaf fibre mechanically, thermally and morphologically. The research work focusing on developing the green technology for future that can replace the usage of synthetic fibres (carbon, glass, aramid, Kevlar). His research work focused on the aerospace application.

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