TENSILE PROPERTIES OF PINEAPPLE LEAF FIBRE REINFORCED UNSATURATED POLYESTER COMPOSITES

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Abstract

In recent years natural fibres such as sisal, jute, kenaf, pineapple leaf and banana fibres appear to be the outstanding materials which come as the viable and abundant substitute for the expensive and non-renewable synthethic fibre. This paper investigate the effect of fibre length and fibre content on the tensile properties of pineapple leaf fibre (PALF) reinforced unsaturated polyester (UP) composites. PALF as reinforcement agent will be employed with UP to form composite material specimens. The various of fiber length (<0.5, 0.5–1, and 1-2 mm) and fibre content (0, 5, 10 and 15 % by volume) in UP composite have been studied. The fabrication of PALF/UP composites used hand lay-up process, and the specimens for tensile test prepared follow the ASTM D3039. The result obtained from this study show that the 1-2 mm fibre length has higher tensile strength (42 MPa) and tensile modulus (1344 MPa) values compared to fibre length of <0.5 mm (30 MPa and 981 MPa) and 0.5-1 mm (35.40 MPa and 1020 MPa) respectively. Meanwhile, for the effect of various fibre content in study has shown that the increase of fibre content has decreased in tensile strength dan tensile modulus of composites. The increase of fibre content due to poor interfacial bonding and poor wetting of the fibre by unsaturated polyster. The treatment of natural fibre are suggested in order to improve the interfacial adhesion between natural fibre and the unsaturated polyester.

Introduction

At present, there are many studies conducted on natural fibres to replace synthetic fibres as reinforcement in which the development of natural fibre composites has been in the limelight for a few years before. Natural fibres are more economical when used as reinforcement in polymer composites compared with synthetic fibres.

Recently, the research community has shown growing interest in using PALF as to reinforce thermoplastic and thermoset polymer composites due to their excellent mechanical properties compared to those of other natural fibers [1]. From previous studies, epoxy, polyester, phenol formaldehyde (PF), and vinyl ester are typical thermosets used in natural fiber-reinforced composites, with epoxy being the most widely used [2-5].

The objective of the present work paper is to investigate the effect of fibre size and fibre content on the tensile properties of PALF/UP composites.

Methodology

Preparation of materials

The unsaturated polyester (UP) used as the thermosetting polymer was ETERSET 2504APT-5 supplied by Eternal Chemical CO., LTD. The pineapple leaf fibres were obtained from Pemalang, Central of Java, Indonesia. Before processing, the fibres were ground and sieved into different sizes of fibres which were 0.5, 0.5-1, and 1-2 mm. PALF fibres were placed into vacuum oven at the temperature of 80^{o}C for 24 hours before mixing process.

Fabrication of Specimen

Hand lay-up technique is a technique that used in this study to fabricate the composite specimen. Hand layup technique also known as wet layup technique. These composite materials are prepared using a closed mould with the dimension of 360 x 280 x 5 mm. For mixing process of composite specimen, the UP and PALF mix together. The whole mixture must stir slowly to avoid the formation of bubbles. After that the mixture was poured in the mould. The composition of fibre length and fibre content are presented in Table 1. The composite was allowed to cure at room temperature. Each composite plate was cut into specimen size based on ASTM D3039.

Table 1
Mixing process of PALF/UP composite

PALF/UP	Fibre length (mm)	PALF content (vol.%)	UP (vol.%)
PALF/UP (5 % vol. of fibre)	< 0.5	5	95
	0.5-1	5	95
	1-2	5	95
PALF/UP (1-2 mm length of fibre)	Pure UP	0	100
	1-2	5	95
	1-2	10	90
	1-2	15	85

Testing

The tensile test were conducted according to ASTM D3039 using Instron universal testing machine with load cell 10 kN, using crosshead speed of 1 mm/min. Test was performed until tensile failure occurred. Seven specimens were tested and at least five replicate specimens were presented as an average of tested specimens.

Results and discussions

The Fig. 1 illustrates the tensile strength and tensile modulus of PALF/UP composites with different sizes of fibre. As observed from the graph, the addition of 5 % vol. fibre with < 0.5 mm length of fibre in UP composite, the tensile strength and tensile modulus is about 29.80 MPa and 981 MPa respectively. Meanwhile, the addition of 0.5-1 mm and 1-2 mm size of fibre significanly increase of the tensile strength dan tensile modulus of composite from 35.40 MPa to 42.30 MPa and 1020 MPa to 1344 MPa rspectively. The result of the investigation shows that the increase size of fibre from < 0.5 mm to 1-2 mm has increase the tensile strength of PALF/UP composites.

The results of this study indicate that the fibre length has profound impact on the properties of composites. Beside holding the fibres together, the matrix has the important function of transfering applied load to the fibres. The efficiency of a fiber reinforced composite depends on the fiber-matrix interface and the ability to transfer stress from the matrix to the fiber [6]. In short fibre size (< 0.5 mm), tensile strength is low due to the fact that length may be not sufficient enough for

proper distribution of load. As proper length is not availabe for stress distribution, failure of specimens occcurs easily.

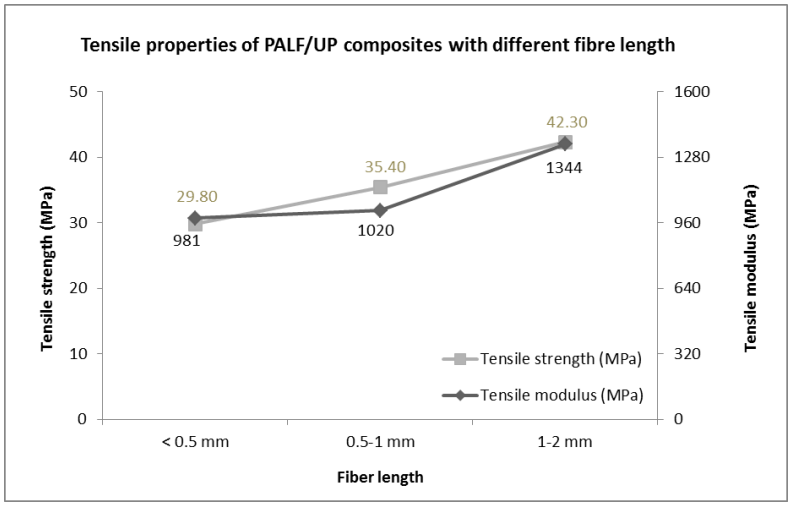

Fig. 1. Tensile properties of PALF/UP composites with different fibre length.

The Fig. 2 shows the effect of different fibre sizes on the tensile properties of PALF/UP composites. For specimen without fibre inclusion (pure UP), the measured tensile strength and tensile modulus are about 56.6 MPa and 1237 MPa respectively. The increase of fibre content from 0 to 15 %vol. has decreased the tensile strength and tensile modulus of PALF/UP composites. The addition of 5% PALF in UP composites the tensile strength has decreased of 25 % (42.30 MPa). The tensile modulus increase by 8%, from 1237 MPa to 1344 MPa, when the fibre content increased from 0% to 5%. The fibres volume changing from 5 to 15%, the tensile strength and tensile modulus decreased as increasing of the fibre volume fraction. The highest fibre content (15%) in UP composites has lowest tensile strength (26.10 MPa) and tensile modulus (869 MPa). The decrement of tensile strength on natural fibre composite is due to the weak bonding between the fibre and matrix. In addition, fibre agglomerations also lead to uneven dispersion in matrix, thus weakening the tensile strength of the material [7,8].

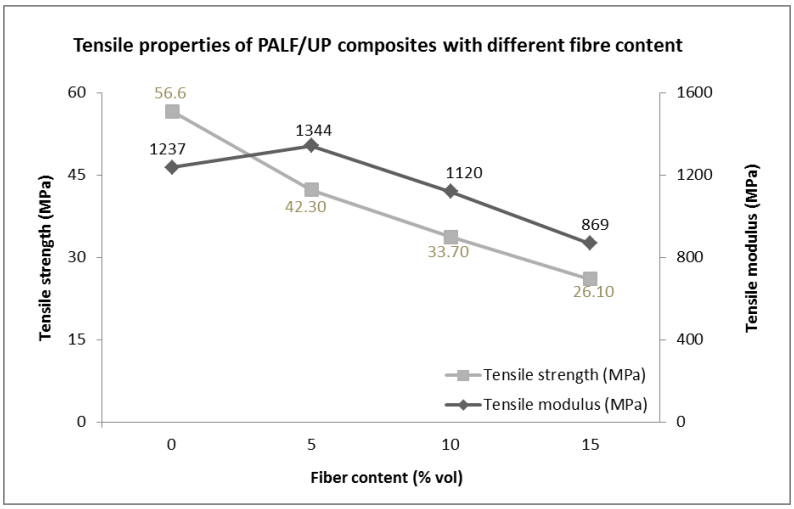

Fig. 2. Tensile properties of PALF/UP composites with different fibre content

Conclusion

The effect of fibre length and fibre content on the tensile properties of PALF/UP composites has been studied. The PALF/UP composites with longer fibre (1-2 mm) has highest tensile strength and tesile modulus compare to the other sizes of fibre. The probable reason is that a long fiber may become compatible with the matrix propely. Meanwhile, the increase of fibre content up to 15 %vol. has decreased significantly the tensile strength of composite due to poor bonding of fibre by the matrix and also the increase incompatibility between hydrophilic (natural fibre) and hydrophobic (matrix) materials will effect the performance of the composites.

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