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Effect of Maleic Anhydride Polypropylene on Flexural Properties of Hybrid Kenaf - Sugar Palm Fibre Reinforced Polypropylene Composites

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ABSTRACT

This study was focused on the characterize the hibridisation of kenaf and sugar palm fibre in reinforcing the polypropylene matrix. Addition of MAPP (Maleic Anhydride Polypropylene) was used as compatibilizing agent with variation of 2%, 3% and 5%. The specimen materials were prepared with 30% amounts of fibres while the ratios between kenaf and sugar palm fibre are 10:20, 15:15 and 20:10. The composites were fabricated using melt mixer technique and followed by compression molding process. The specimens were cut according ASTM Standard D790 for conducting the flexural testing. After testing done, the results shown that flexural strength of composites tend to decreased when the content of MAPP increased. The ultimate flexural strength was attained at 2% MAPP addition of the hybrid composites with 20% kenaf fibres. Among the composites with different ratios, the hybrid composites that contain more kenaf fibres exhibit the higher value in flexural strength than the composites that contain more sugar palm fibres.

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KEYWORDS

Hybrid; kenaf; sugar palm; fibre; polypropylene; MAPP.

ABSTRAK

Penelitian ini mengkaji sifat-sifat hibridisasi serat kenaf dan ijuk dalam memperkuat matriks polipropilen. Penambahan MAPP (Maleic Anhydride Polypropylene) digunakan sebagai bahan penyesuai dengan variasi 2%, 3% dan 5%. Spesimen uji dibuat dengan kandungan serat 30% dan rasio antara kenaf dan ijuk adalah 10:20, 15:15 dan 20:10. Komposit dibuat menggunakan mesin melt mixer dan dilanjutkan dengan proses pencetakan kompres. Benda uji dipotong sesuai Standar ASTM D790 untuk melakukan pengujian lentur. Setelah dilakukan pengujian, hasilnya menunjukkan kekuatan lentur komposit cenderung menurun seiring dengan peningkatan MAPP. Kekuatan lentur tertinggi dicapai pada penambahan 2% MAPP pada komposit hibrida dengan 20% serat kenaf. Di antara komposit dengan rasio serat yang berbeda, komposit yang mengandung lebih banyak serat kenaf menunjukkan nilai kuat lentur yang lebih tinggi dibandingkan komposit yang mengandung lebih banyak ijuk.

KATA KUNCI

Hibrid; kenaf; ijuk; serat; polipropilen; MAPP.

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1. Introduction

The demand for sustainable and environmentally friendly materials has fueled extensive research into the development of biocomposites as alternatives to traditional synthetic polymers [1]. In this context, natural fiber reinforced polypropylene (NF-PP) composites have garnered significant attention due to their renewable nature, low environmental impact, and potential for enhanced mechanical properties [2]. Among the various natural fibers, kenaf and sugar palm fibers have emerged as promising reinforcements, offering a unique combination of strength, lightweight, and biodegradability [3][4]. Despite their inherent advantages, challenges associated with the compatibility between hydrophilic natural fibers and the hydrophobic polypropylene matrix hinder the realization of their full potential in composite applications. Then, the loads are not full enough transferred between fibre and matrix when the composites used as structural materials. This has prompted the use of coupling agents, such as maleic anhydride polypropylene (MAPP), to enhance the interfacial adhesion and overall performance of these biocomposites [5][6].

Hybrid composites involving natural fibers represent a unique class of materials that combine the advantages of two or more types of natural fibers within a single matrix [7][8]. These composites typically utilize a blend of plant-derived fibers, such as jute, flax, or hemp, to enhance specific mechanical, thermal, or environmental properties. The incorporation of multiple natural fibers allows for a synergistic effect, where the individual strengths of each fiber type complement one another, resulting in a composite material with improved overall performance. Hybridization offers designers and manufacturers the flexibility to tailor the composite to meet specific application requirements, balancing factors like strength, stiffness, and weight. Additionally, the use of natural fibers in hybrid composites aligns with sustainability goals, as these materials often have a lower environmental impact compared to traditional synthetic reinforcements, contributing to the growing interest in eco-friendly and bio-based composite solutions. However, hybrid composites that prepared by two types of natural fibres as reinforcing agents still face many challenges. The researchers target is to achieve the best utilization of the positive attributes of one fibre and to have been get full attention due to reduce its negative attributes as far as practicable. Combining sisal with oil palm fibres [9], hemp with kenaf fibre [10], and kenaf with pineapple leaf fibre [11] are some examples of studies of hybrid composites reinforced by two types of natural fibres.

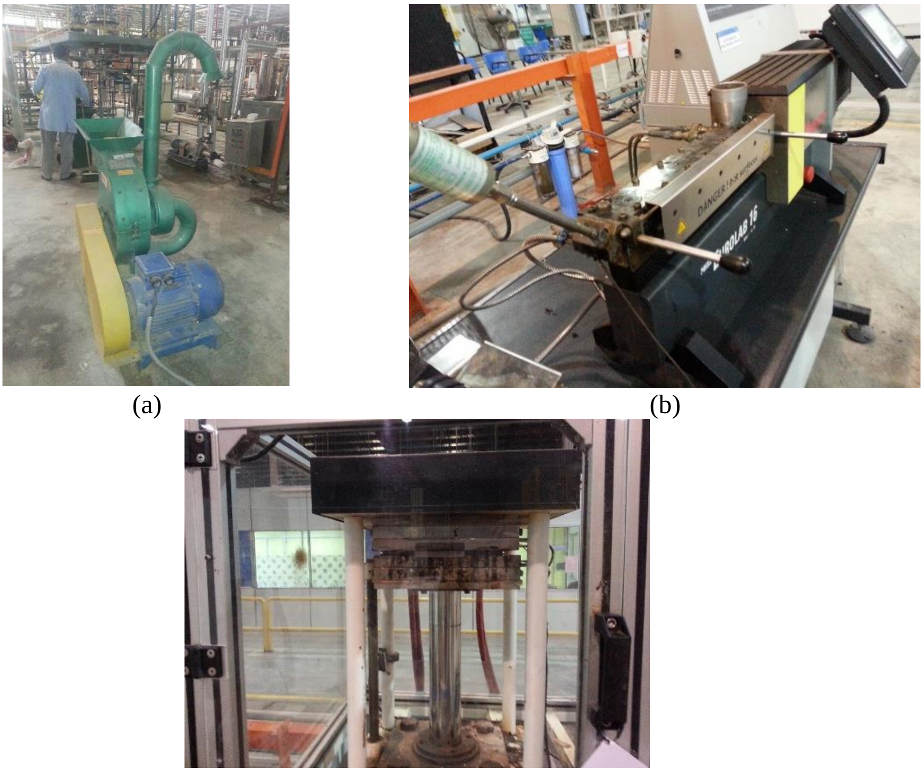
This paper investigates the specific influence of maleic anhydride polypropylene on the flexural properties of hybrid kenaf and sugar palm fiber reinforced polypropylene composites. Flexural properties, a critical determinant of the material's structural integrity and performance, are influenced by the interplay of fiber-matrix adhesion, fiber dispersion, and the overall composite architecture. Understanding the effects of MAPP on the flexural behavior of these hybrid composites is essential for optimizing their mechanical performance and expanding their applications in areas such as construction, automotive, and packaging. Through a systematic examination, this study aims to contribute valuable insights into the tailored use of coupling agents to improve the flexural characteristics of natural fiber reinforced polypropylene composites.

2. Research Methods

The materials that used in this study were kenaf fibres, sugar palm fibres, polypropylene (PP) and maleic anhydride PP as coupling agent. Kenaf fibres were obtained from KEFI Kelantan while sugar palm fibres were obtained from local market in Aceh, Indonesia. Polypropylene pellet was supplied by Petrochemical (M) Sdn Bhd, Pasir Gudang, Johor, Malaysia. The material of maleic anhydride PP was supplied by Sigma-Aldrich.

2.1 *Preparation of Hybrid Composites*

The Kenaf and sugar palm fibres were crushed using chrushing machine (see Figure 1(a)) and produced the short fibre. Then the sieving machine was used to process the fibres into uniform size of with 0.1 – 0.5 mm. Compounding of short sugar palm fibres, kenaf fibres, MAPP and PP matrix was carried out using an extruder machine (see Figure 1(b)) according compositions as shown in Table 1. The mixing temperature and rotation speed were set at 170 C – 190 C and 50 rpm respectively. The hybrid composites produced by this extruder in long form and then after cooled were cut into short material as a pellet form. The hot press machine (see Figure 2) was used to process the pellet form of hybrid composites into plate with 200 mm x 200 mm x 5 mm size. was placed in the compression mould, heated at a temperature of 170 °C and endured the process of preheating for 5 min. Heating was carried out for 5 min followed by cooling for further 5 min. The specimens for the mechanical tests were obtained from these plates of composites.



(a) (b) (c)

Figure 1. (a) Crushing machine for fibres, (b) Extruder machine for compounding the composites, (c) Hot press machine

Table 1. Composition of Hybrid Composites

No.	Type of Composites	Weight Percentages of Content			
		Kenaf	Sugar Palm	MAPP	PP
1	10K20SP2MAPP	10	20	2	70
2	15K15SP2MAPP	15	15	2	70
3	20K10SP2MAPP	20	10	2	70
4	10K20SP3MAPP	10	20	3	70
5	15K15SP3MAPP	15	15	3	70
6	20K10SP3MAPP	20	10	3	70
7	10K20SP5MAPP	10	20	5	70
8	15K15SP5MAPP	15	15	5	70
9	20K10SP5MAPP	20	10	5	70

2.2 *Mechanical Testing*

Flexural tests were also conducted using the universal testing machine according to ASTM D790 standard (see Figure 3). The specimen geometry for the flexural test was 127(L) x 12.7(W) x 3(T) mm, that were cut the previous plates of hybrid composites from product of hot press process. Then, the specimen was attached to pose the three point bending procedure. The specimen of composites were loaded until it was fractured. The gauge length was 48 mm with a crosshead speed of 1 mm/min.

Figure 2. The Instron Universal Testing machine for Evaluate Flexural Properties

3. Results and Discussion

3.1 *Flexural Strength*

From Figure 1, experimental results are obtained for the maximum flexural strength achieved by material type 20K10SP2MAPP, namely 60.14 MPa.

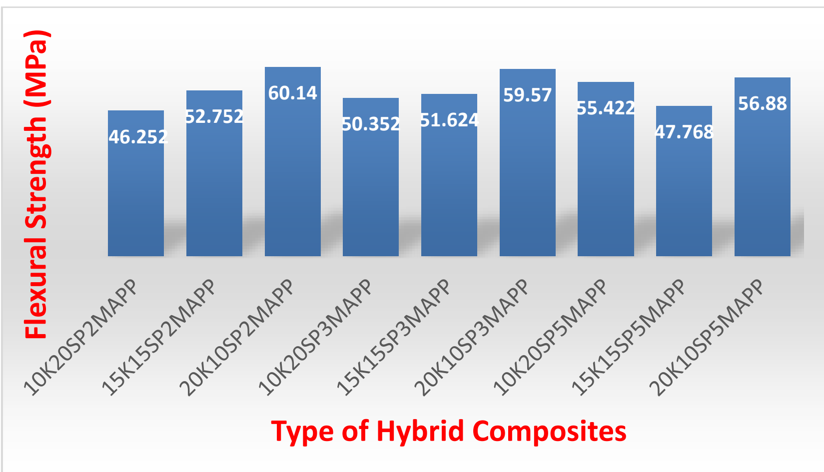


Figure 3. Flexural Strength for Hybrid Kenaf/Sugar Palm Fibre PP Composites

The effect of adding MAPP as a compatibilizing agent of 2% provides maximum value. So the addition of MAPP of 3 and 5% does not have much of an effect on increasing flexural strengths. So, the adding the 2% MAPP become the optimum condition when it used as compatibilizing agent in this composites. Maleic anhydride grafted polypropylene (MAPP) serves as a compatibilizing agent in natural fiber-reinforced composites by improving the adhesion and bonding between the natural fibers and the polymer matrix. Composites often face challenges due to the inherent differences in the chemical composition and polarity of natural fibers and the polypropylene matrix. MAPP contains both hydrophobic polypropylene and a maleic anhydride functional group.

The maleic anhydride moiety can react with hydroxyl groups present on the surface of natural fibers, creating covalent bonds between the fibers and the matrix. This chemical linkage enhances the interfacial adhesion, reducing the potential for debonding or delamination during mechanical stress. Additionally, MAPP's polypropylene component contributes to compatibility by promoting adhesion with the polymer matrix itself. Through these dual mechanisms, MAPP acts as a bridge, facilitating a stronger and more durable connection between the natural fibers and the polymer matrix, ultimately improving the overall performance and mechanical properties of the composite material.

The hybrid composite in this experiment combines two types of natural fibers, namely kenaf and sugar palm fiber, in a reinforced polypropylene matrix. From Figure 1, it can be seen that the composite containing dominant kenaf provides the best flexural strength effect. This result is similar to that shown for tensile strength where the kenaf content which is more dominant than sugar palm gives better results. This is quite natural considering that the strength of single kenaf fiber is still superior to single fiber sugar palm. This could be supported by the celulose content in kenaf which is still higher than the celulose content in seart sugar palm [12].

3.2 *Flexural Modulus*

The flexural modulus characterize the level of stiffness for the composites. Figure 2 indicate the flexural modulus of the hybrid composites. It is shown that the MAPP addition has a slight effect on increasing the stiffness of these materials. The ultimate stiffness was shown by 10K20SP5MAPP specimen with 5%MAPP, namely 2807 MPa.

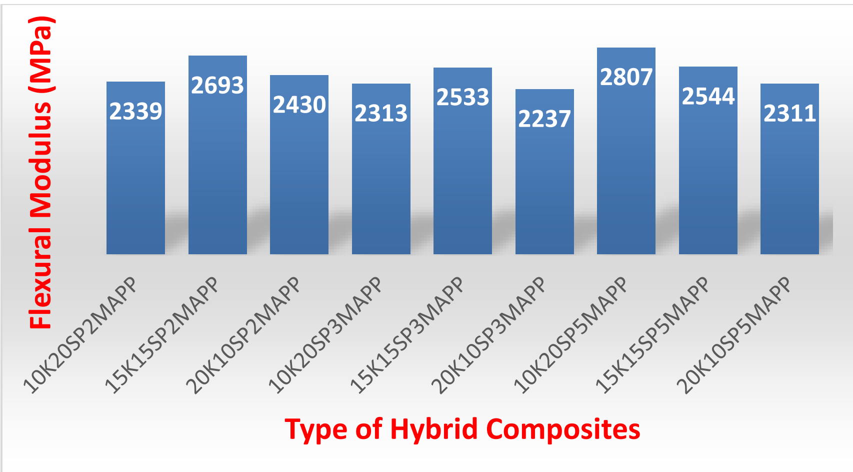


Figure 4. Flexural Modulus of Hybrid Kenaf/Sugar Palm Fibre PP Composites

Maleic anhydride grafted polypropylene (MAPP) plays a crucial role in enhancing the flexural modulus of composites. The flexural modulus is a measure of a material's stiffness and resistance to bending or deformation under applied load. In composite materials, particularly those incorporating natural fibers achieving an optimal balance of strength and stiffness is essential for various applications. MAPP serves as a compatibilizing agent in these composites, promoting better adhesion and bonding between the natural fibers and the polymer matrix, typically polypropylene or polyethylene. By forming covalent bonds between the maleic anhydride functional groups in MAPP and the hydroxyl groups on the surface of natural fibers, it creates a stronger and more effective interface.This improved interfacial adhesion prevents the occurrence of microscale failures, such as debonding or fiber pull-out, during flexural loading. As a result, the MAPP-treated natural fiber-reinforced composite exhibits enhanced resistance to bending and better load distribution between the fibers and the matrix. The increased compatibility introduced by MAPP contributes to a more efficient load transfer mechanism, ultimately leading to a higher flexural modulus for the composite material.

4. Kesimpulan

Investigation on the effect of MAPP addition on the flexural properties of hybrid kenaf/sugar palm fibre reinforced polypropylene composites have been successfully conducted. In conclusion, the comprehensive investigation into the flexural properties of hybrid kenaf and sugar palm fiber reinforced polypropylene composites, particularly in the presence of maleic anhydride polypropylene, reveals a noteworthy dominance of kenaf fibers over sugar palm fibers. The synergistic effects of kenaf fibers contribute significantly to the enhanced flexural performance of the composite, highlighting their superior mechanical properties and reinforcing capabilities when combined with the polypropylene matrix. This finding underscores the potential of kenaf fibers as a dominant and influential component in the development of high-performance hybrid biocomposites, paving the way for their utilization in various engineering applications requiring superior flexural strength and durability.

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