PHYSICAL AND MECHANICAL PROPERTIES OF NATURAL FIBERS/RECYCLED POLYPROPYLENE COMPOSITES

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ABSTRACT

PHYSICAL AND MECHANICAL PROPERTIES OF NATURAL FIBERS/RECYCLED POLYPROPYLENE COMPOSITES. Interest in the use of natural fibers has grown during the last decade due to their low costs and the search for renewable sources. Composites consisting of biorenewable fibers wood (*Acacia mangium*), water hyacinth (*Eichornia crassipes*), kenaf (*Hibiscus cannabinus*), and banana (*Musa paradisiaca*) and recycled polypropylene (RPP) were prepared by extrusion process based on a ratio of 50:50% (w/w) with an addition of 2% polypropylene modified with maleic anhydride. Physical and mechanical properties of natural fibers/RPP composites were evaluated. The results showed that fiber origin affected the physical and mechanical properties of composites. Composites filled with banana fiber shows better physical and mechanical properties than other fibers. The tensile and flexural properties of composites as well as RPP did not change by a six days wet-dry treatment.

Key words : Natural fiber, recycled polypropylene, composite, waste

ABSTRAK

SIFAT FISIKA DAN MEKANIK KOMPOSIT POLIPROPILEN DAUR ULANG SERAT ALAM. Penelitian ini dilakukan untuk mengevaluasi kemungkinan digunakannya serat alam dari kayu (*Acacia mangium*), eceng gondok (*Eichornia crassipes*), kenaf (*Hibiscus cannabinus*), dan pisang (*Musa paradisiaca*) sebagai bahan pengisi pada komposit polipropilen daur ulang. Evaluasi dilakukan terhadap sifat fisis dan mekanis komposit polipropilen dengan pengisi serat alam. Komposit dibuat dengan cara ekstrusi. Perbandingan serat alam dan polipropilen adalah 50:50% (b/b) dengan penambahan 2% maleat anhidrid polipropilen. Sifat fisis dan mekanis yang diuji adalah ketahanan terhadap air (pertambahan berat, pertambahan tebal, ekspansi linier), kekuatan tarik, dan kekuatan lentur. Hasil penelitian menunjukkan bahwa komposite polipropilen daur ulang dengan pengisi serat pisang memiliki sifat tarik dan sifat lentur yang lebih baik dibandingkan dengan komposit lain.

Kata kunci : Serat alam, propilen daur ulang, komposit, limbah

INTRODUCTION

Wood polymer composites (WPC) is increasingly popular in the world today. However, with the diminishing supply of the wood, an alternative raw material is needed. Underutilized natural fiber residues are a readily available rich resources of ligno-cellulose materials. In spite of its cheapness and availability in a large quantities, presently there exists only a minor quantity for its utilization. Since the last decade, composites consisting ligno-cellulose fibers and synthetic thermoplastics have received substantial attention in scientific literature as well as industry [1, 2], primarily due to improvements in process technology and economic factor. The use of ligno-cellulose fibers in plastic composites is of particular interest because such fibers can serve as a good reinforce and/or filler for synthetic polymers to enhance certain properties while reducing material cost [3].

These fibers have many advantages, such as low density, high specific strength and modulus, relative non- abrasiveness, ease of fiber surface modification, and wide availability [4]. Conversion of these materials into useful industrial products leads to a win–win situation economically by creating jobs, and ecologically by alleviating waste disposal problems. Studies on the polypropylene composites filled with ligno-cellulose fibers have been reported [5-7].

However, little is known about using acacia, water hyacinth, kenaf, and banana in recycled polypropylene composites. This study aimed to evaluate the suitability of wood (*Acacia mangium*), water hyacinth (*Eichornia crassipes*), kenaf (*Hibiscus cannabinus*), and banana (*Musa paradisiaca*) as filler in recycled polypropylenes (RPP).

EXPERIMENTAL METHOD

Sample Preparation

All natural fibers (100 mesh) were used as filler and dried in an oven at 100°C for 24 h, and its moisture content was controlled within 2–3%. Recycled polypropylene (RPP) obtained from a local plastic company and used as matrix. Its melting temperature was 167 °C. The tensile strength and modulus of RPP after extrusion were 28 and 695 MPa, respectively. This polymer was selected as the matrix because its virgin polymer of the major commodity plastics and processed below the decomposition temperature of lignocellulosic fiber. In this study, maleated polypropylene (MAPP) Toyotac M-300 supplied by Toyoseiki Kogyo was used as a coupling agent for natural fiber/recycled polypropylene composites. Coupling agents are generally used to modify the fiber–matrix interface and thereby enhance the fiber–matrix adhesion. Toyotac M-300 has a weight-average molecular weight of 40,000 was about 6% by weight of maleic anhydride. The concentration level of MAPP was 2,5% with respect to the weight of RPP.

Extrusion

A Laboplastomill extruder (Toyoseiki, 30R-150) single screw was used with a die that produced 3 mm radius edge profile and its temperature was 175°C. Extrusion speed was 10 rpm. RPP was blended with natural fibers in four repetitions. MAPP was added during the third extrusion. The extruded granule samples were then extruded with a rectangular die produced a tape shape flat specimen. A total weight (fiber, RPP, and MAPP) of 505 gram were used for each batch, and about 250 gram of extruded material was prepared for each set of experiments. The total residence time of the extrusion operation was dependent on the fiber type. Composites were made from 50 percent (weight) of fiber and 50 percent (weight) of RPP. For comparison, RPP was extruded without any fiber addition.

Wet-dry Treatment

Samples for tensile and flexural test were treated by wet-dry treatment. One cycle of the treatment is one hr immersing in water at 25 °C, followed by air dried at 100 °C. One day consists of 12 cycles. Wet-dry treatment was carried out for 0, 1, 3, and 6 days.

Testing of Extruded Samples

Samples were conditioned at 23 °C, RH 50% for a minimum 40 hr before testing. Tensile and flexural test were carried out according to ISO-527 and ASTM D-790on an Universal Testing Machine (Orientec UCT-5T) using 5 specimens at a cross head rate of 1 mm/min. All the mechanical properties were performed at room temperature (23 °C, 50%). Water resistant was determined by measuring the time-dependent change of the weight gain, thickness swelling and linear expansion of the test pieces after immersing into water at 25 °C for 1, 7, and 30 days.

RESULTS AND DISCUSSION

Physical Property

Moisture absorption can result in swelling of the fiber resulting in dimensional stability problems in the lignocellulosic fiber composites [8,9]. However, moisture absorption can have some secondary benefits, such as reducing static electricity in the final plastic object. Water absorption of lignocellulosic fiber composites are important characteristics that determine end use applications of these materials. Water absorption could lead to a decrease in some of the properties and should be considered when selecting applications. Water absorption properties corresponding with weight gain is shown in Figure 1. As for seen, the addition of fiber increased water absorption of composites. RPP

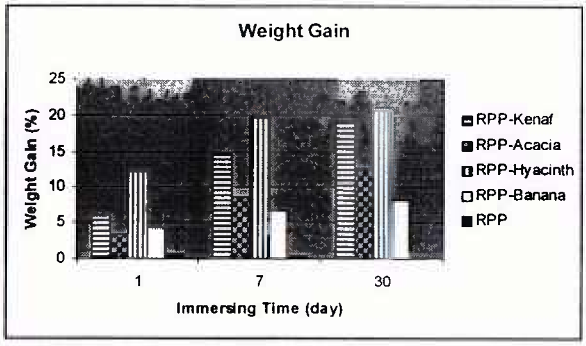


Figure 1. Weight gain of the composites after immersing in water

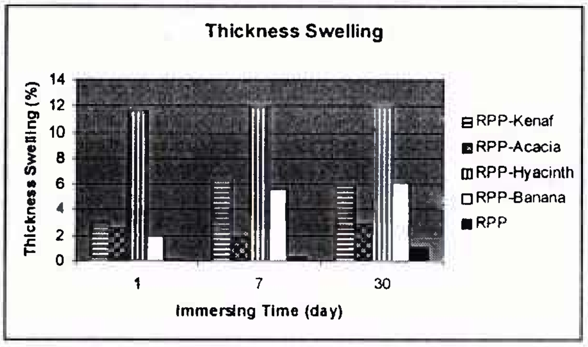


Figure 2. Thickness of composites after immersing in water

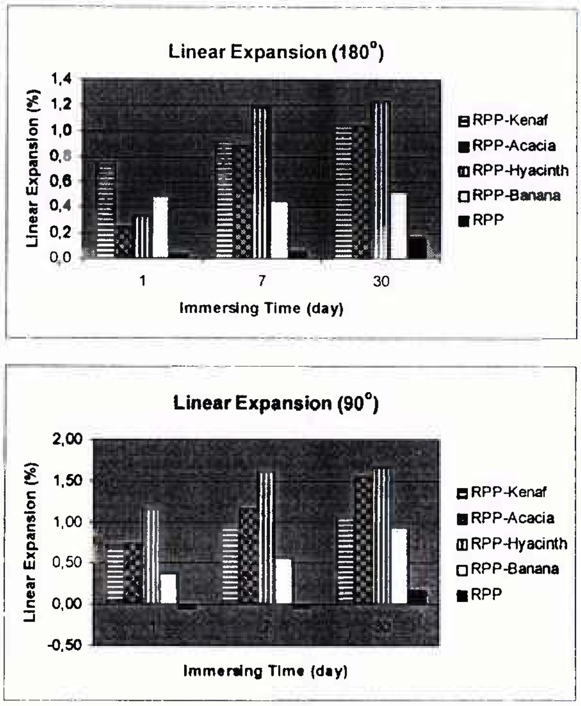


Figure 3. Linear expansion of the composites

composite filled with banana fiber responded significantly low in water absorption. In contrary, water hyacinth filler demonstrated high weight gain. There was a significant effect of natural fiber as filler on the thickness swelling after 30 days of immersion in water (Figure 2). The thickness effect was more pronounced for the composites with water hyacinth as filler. It explains why, RPP composite with water hyacinth was most susceptible for water absorption. Linear expansion (180° and 90°) of composites are shown in Figure 3. A low linear expansion of banana fiber was observed for the RPP composite. In contrast, the composite filled with water hyacinth was susceptible to water absorption.

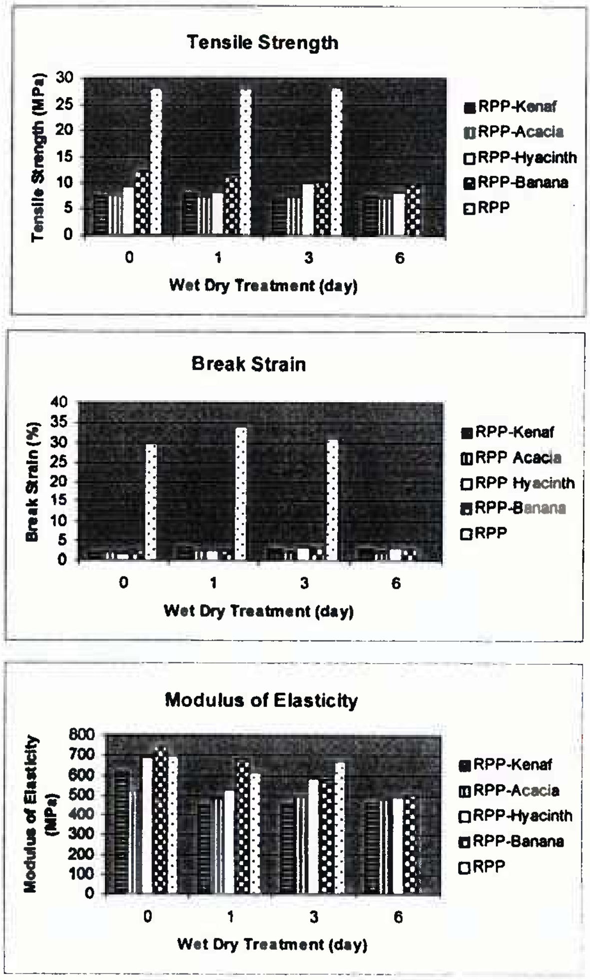
Mechanical Properties

Tensile

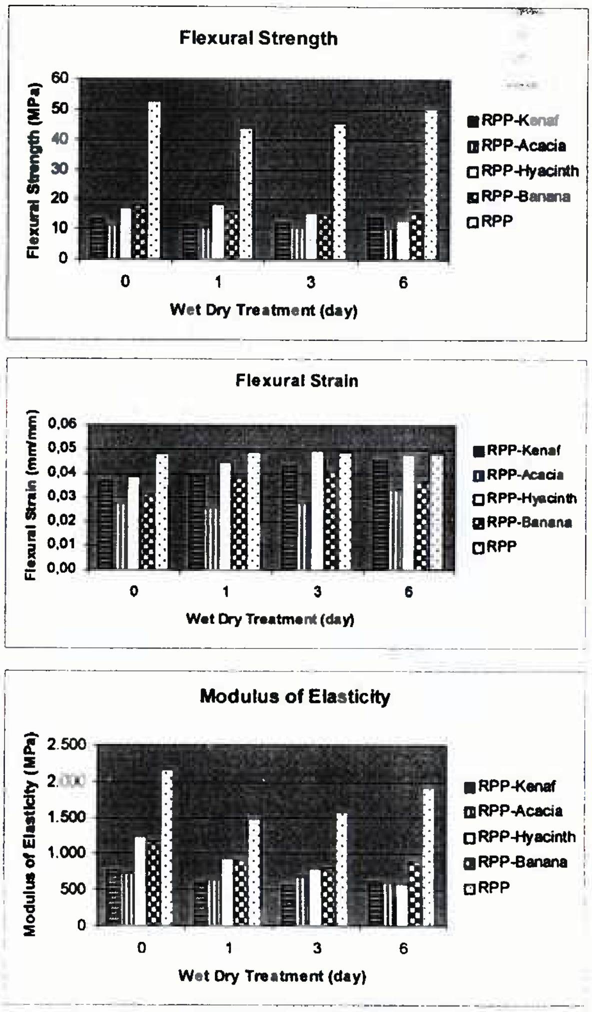
Compared with virgin polypropylene (tensile strength of 30-40 MPa, break strain of 200-700 % and modulus of elasticity of 1100-1600 MPa (9), mechanical properties of RPP is low namely tensile strength 28 MPa, break strain 30 %, and modulus of elasticity 695 MPa (Figure 4). Recycling process and five repetitions of RPP and natural fibers during extrusion may caused this property alleviation. RPP filled with natural fibers exhibited lower tensile strength and break strain compared with RPP. Banana fiber/RPP shows high tensile strength property compared with other fibers. Tensile strength and break strain of RPP and natural fibers/RPP composites are not altered by the six days wet-dry treatment. On the other hand, the treatment reduced the modulus of elasticity of the composites significantly.

Flexural

Composites filled with natural fibers have a low flexural strength and modulus of elasticity than of RPP (Figure 5) which could be due to the poor interaction between the hydrophilic natural fibers and RPP. Banana fiber/RPP shows high flexural property compared with other fibers. Flexural strength property of the composites were not altered by six days wet-dry treatment but on the flexural strain and modulus of elasticity. However, RPP resisted by this treatment. Banana fiber as a



Gambar 4. Tensile properties of the composites



Gambar 5. Flexural properties of the composites

filler for the composites has a high flexural properties than others.

CONCLUSION

Fiber origin affected the physical and mechanical properties of composites. Banana fiber was found to resist to water absorption and relatively better tensile and flexural properties than other fibers. The tensile and flexural properties of composites and RPP did not change by a six days wet-dry treatment.

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