Effects of the Coconut Pulp Fiber on the Mechanical Properties and Water Absorption of Reinforced Ethylene Propylene Diene Monomer

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Abstract This study investigated the effect of Coconut Pulp (CP) fiber on the mechanical properties of Ethylene Propylene Diene Monomer (EPDM). CP filled EPDM composites were prepared by using a mixer and hot press. There are four types of the composition of CP, 10, 20, 30 and 40%. In this study, the tensile strength, modulus of elasticity, elongation at break and water absorption of the composites were evaluated. The tensile strength and elastic modulus decreased while elongation at break increased with the increasing of CP fiber. A lab microscope used to study the morphology of CP in EPDM. Four different types of water used in the water absorption test: Sea, swamp, well and pipe water.

Keywords Coconut pulp fiber · EPDM · Mechanical properties
Water absorption

1 Introduction

Ethylene propylene diene monomer (EPDM) is one of the thermoplastics commonly used in the automotive industry. Several applications of EPDM in the automotive industry are known, such as dashboard wrap material; cushion wrap and some vehicles use it as roof cover [1]. EPDM properties such a resistance to stress, low density, high tensile strength, chemically inert, heat resistance and recyclable

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that make it an eco-friendly material [2]. However, the usage of degradable polymers is expensive. Thus, the usage of natural filler can reduce the cost of the entire composites. In addition, the natural filler can also act as a strengthening agent for polymer composites.

Many researchers have found that petrochemical-based fillers such as carbon black are suitable as filler material, utilizing the natural fiber as a substitute in composite materials. The coconut pulp (CP) fiber as shown in Fig. 1 is one of the highly potential substitute for synthetic filler and petrochemical filler. The low cost of coconut pulp is one of the major factors for this filler selection. The humidity on coconut pulp becomes the major problem for the natural fiber composites. It reduces the adhesion properties of the fiber. In order to counter this problem, surface treatment conducted to improve the surface roughness and it promotes the bonding between matrix and filler.

The natural fibers are environment-friendly as compared to the steel and synthetic fibers. Natural fibers are low cost, and the coconut fibers are abundantly available in tropical regions [1, 2]. In this study, the discrete (or chopped) fiber type is use for the composite. The disadvantage for this type of fiber is that the strength lower than aligned fibers, however, the material used is isotropic and cheaper [3]. Figure 2 shows the illustration of a random fiber arrangement.

Thermoplastic elastomers (TPE) are elastomers as shown in Fig. 3 and can be processed like a thermoplastic. It does not require a complex system of chemicals for crosslinking as do normal rubbers and they can be recycled. The properties of TPE can be improved by the addition of different fibers. The composite mixed by using a hot mixing machine as shown in Fig. 4. High temperature and pressure ensured the CP mixed evenly in the elastomer [4]. A dumbbell-shaped specimen according to ASTM D638 has been molded using the hot press machine. Figure 5 shows the hot press machine and the mould.

Fig. 1 Coconut pulp

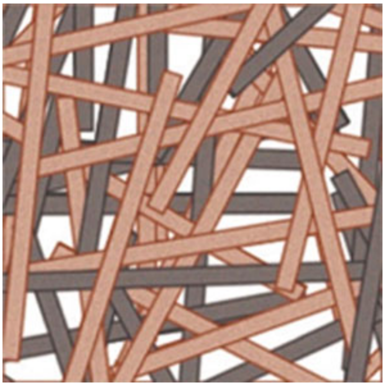

Fig. 2 Illustration of random fiber arrangement

Fig. 3 Elastomer

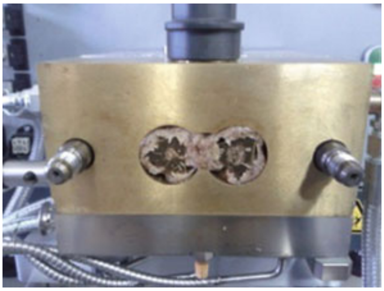

Fig. 4 Hot mixing process

2 Methodology

Materials

The CP contains oil and humidity. The CP was washed and dried in an oven for about 12 h at 55 °C before being mixed. The loading ratio (wt%) for the filler is 10, 20, 30 and 40%. The elastomer or EPDM was pre-heated with 160 °C for 6 min. The CP fibers were added and heated for another 5 min. Dumbbell shape specimen was produced by using a mould and hot press machine. The temperature setup was 160 °C and pressed with 1000 N force.

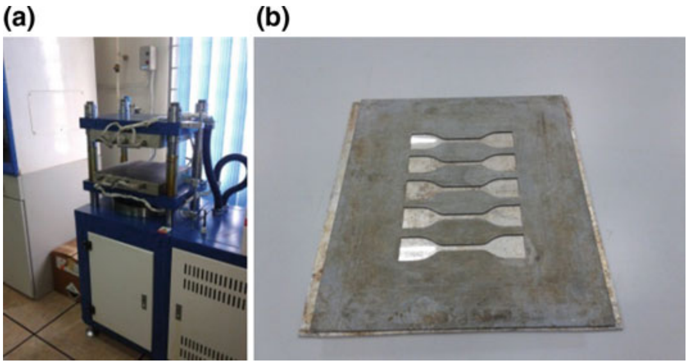

Fig. 5 **a** Hot press machine **b** Moulding

Tensile Test

The tensile test is conducted according to ASTM (D638) and dumbbell shape (Type IV) specimen is needed for the test. The test was conducted in a standard laboratory atmosphere of 23 ± 2 °C and 50 ± 5% relative humidity. The tensile testing machine cross-head speed is 10 mm/minute.

2.1 Water Absorption

In this experiment, the ability of composite to absorb the humidity was studied. The specimen was submerged in four types of water such as the sea, swamp, well and pipe water. The duration was one week. The change of the specimen at the surface was observed.

Morphology

The morphology was studied by using a laboratory microscope at the Universiti Kuala Lumpur Malaysian Spanish Institute.

3 Results and Discussion

Figure 6 shows the tensile strength results as a function of the filler content in different filler loading. From the results, it is obvious that the tensile strength (σ) and modulus elasticity (E) were decreased when the filler loading (wt%) increased. The elongation (%) increased when the filler loading (wt%) increased. The stress was distributed to the filler and as a result the tensile stress decreased when the filler content increased.

The modulus elasticity also decreased due to the changes in elastomer properties from elastic to plastic [5] as shown in Fig. 7. This is because the CP is harder than

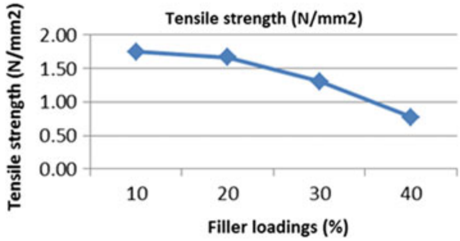

Fig. 6 Tensile strength

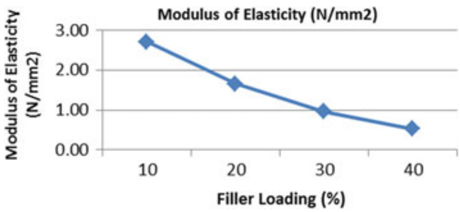

Fig. 7 Modulus of elasticity

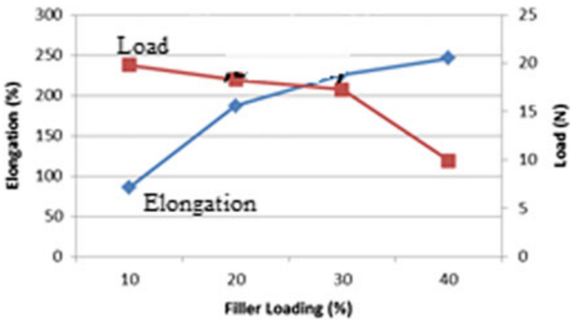

Fig. 8 Elongation and load

the EPDM. The elongation at break increased when the filler loading (wt%) increased as shown in Fig. 8. When subjected to a high load, the higher modulus of the composite will contribute to the higher stress value. When the stress on the composite logically high, it will cause the rate of elongation decreased [5, 6].

Water absorption results are shown in Figs. 9, 10 and 11. When the filler loading (wt%) increased, the water absorption (%) increased. It proved that the fiber absorbs

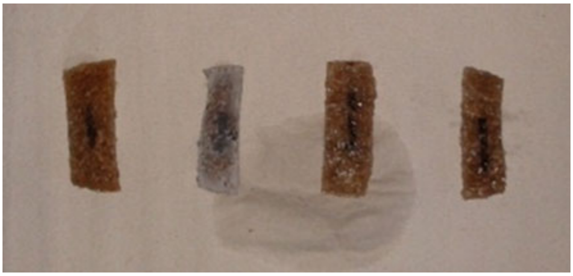

Fig. 9 Effect of Sulphur acid in swamp water changes colour from brown to white

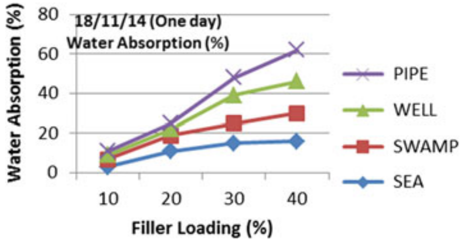

Fig. 10 Water absorption for a period of one day

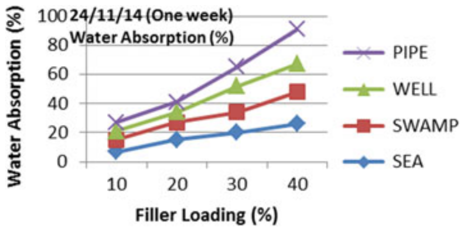

Fig. 11 Water absorption for a period of one week

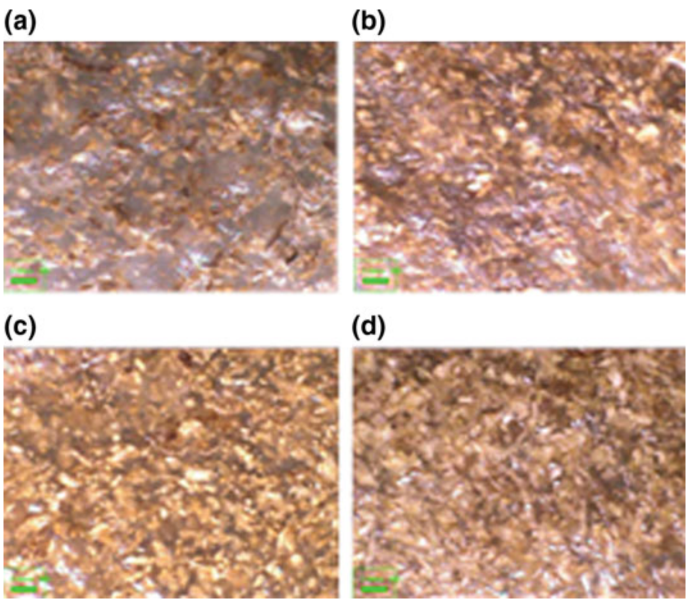

Fig. 12 Morphology results at different filler loading **a** 10 wt% **b** 20 wt% **c** 30 wt% **d** 40 wt%

the water or hydrophilic. The density of seawater is the lowest compared with another three types of water used in the water absorption testing. The sulfur acid that exists in swamp water has affected the surface of the composite. Morphology results in Fig. 12 show the distributions of fiber in every filler loading (wt%) were different. This is due to the amount of fiber or filler used in each mixture.

4 Conclusion

The study proved that with the addition of filler, the value of tensile strength, modulus of elasticity, elongation and water absorption of the composite have changed. As what has been discussed, with the addition of a filler, the tensile strength was decreased due to the stress which is distributed on the fiber weak point. Thus, a filler loading of 10 wt% has the highest strength to withstand induced stress. Moreover, the elasticity modulus decreases when filler loading increases. Apart from that, the elongation percentage of EPDM/ CP composite is increase when filler loading increased. This is due to the reduction of stress in the composite and it allows the composite to stretch longer.

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