Characteristics of coconut shell reinforced thermoplastic composite: thermal, mechanical and morphology properties

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ABSTRACT: The purpose of this study was to study the potential of grain by-product like the coconut shell (CS) as reinforcements for thermoplastic as an alternative and encouraging the usages of natural resource mixed polypropylene (PP) to reduce greenhouse gases. The composite consists of CS (30%, mass fraction) in the PP matrix. CS/PP composites were then fabricated using high speed mixer at 3000 rpm for 5 min and hot press machine to form the tensile and flexural testing specimens. The effect of filler content on the thermal properties, mechanical properties and morphology of CS/PP composites were investigated.

Keywords: *Coconut Shell Composite; TGA; Tensile; Flexural; SEM*

1. INTRODUCTION

The coconut tree (cocos nucifera) is actually under the palm family and plays an important role in the low islands of the Pacific, where it symbolises a major natural resource, providing the livelihood for millions of people [1]. Coconut shell is non-food part of coconut which is hard lignocellulose agro waste. Coconut shell is 15–20% of coconut [2]. Open burning is a common method used to dispose of coconut shells. However, coconut shells can also be a raw commodity for the development of new technologies for manufacturing, namely the bio composite industry [4]. Previous years, cereal lignocellulosic raw material (straw, cornstalk, bagasse) has been used for making composites with polypropylene, polyethylene, polyester, polyvinyl acetate, polyurethane, polylactic acid and novolac resin [3]. Therefore, the aim of this research is to study the effect of filler content on mechanical, morphological, and thermal of CS/PP composite. Some techniques were used to characterize the properties of the blends including SEM, TGA, tensile testing and flexural testing.

2. MATERIALS AND METHODS

2.1 Sample preparation

The coconut shell (CS) is located in between the coconut flesh and coconut husk. The virgin of PP thermoplastics was supplied by a company from the China. The CS was soaked for 2 days in the water and 2 hours in the sodium hydroxide (NaOH) solution to extract the undesired soluble cellulose, hemicellulose, lignin and moisture. Then, it was dried under the sunlight for a day. The CS reinforced thermoplastic was prepared by addition of PP (30 wt% coconut shell-based). Next process would be pre-mixing using high speed mixer at 3000 rpm for 5 min. In order to obtain the tensile and flexural samples the hot press machine brands Gotech with dedicated mold was used in accordance of ASTM D638 and ASTM D790. The hot press process was set at 240 degrees Celsius and 30 minutes for CS/PP composite and 160 degrees Celsius and 20 minutes for virgin PP.

2.2 Thermo-Gravimetric Analysis (TGA)

The data of thermal properties of CS/PP was generated using Thermo-Gravimetric Analyzer. The test was set at 10 degrees Celsius per minute for heating rate and varied the temperature from 25 to 600 degrees Celsius. The test mainly measures the weight loss of the material against the time and temperature as a function continuously.

2.3 Mechanical testing

Tensile and flexural tests were conducted as per ASTM 638 and ASTM D790. The tests were performed using the universal testing machine (Shimadzu model) at the temperature of 23 degrees Celsius and relative humidity of 50±5%. Three samples were measured with a 5kN load cell and 5mm/min crosshead speed.

2.4 Scanning electron microscope (SEM)

The morphology of compounded CS/PP composite was observed by scanning electron microscope, model JEOL (JSM-6010PLUS/LV) using platinum coating and 20 kV acceleration.

3. RESULT AND DISCUSSION

3.1 Thermo-Gravimetric Analysis (TGA)

The thermal analysis result of CS/PP composite and pure PP as shown in Figure 1. As the heating rate increased, the thermal decomposition temperature increased. The decomposition temperature was obtained from the point where weight loss suddenly increased. CS/PP decomposed at 600 degrees Celsius. Meanwhile, pure PP was decayed at 460 degrees Celsius. The more filler amount contains in the material composition; the less time it takes to react.

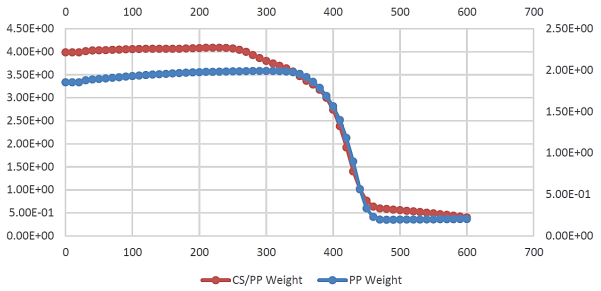

Figure 1 TGA analysis of CS/PP composite and pure PP

3.2 Tensile and flexural properties

The tensile and flexural test of CS/PP and pure PP result display in Figure 2 and Figure 3. The result shows the value of tensile and flexural for CS/PP is lower than pure PP. The mechanical properties of CS/PP composite significantly contrasted while comparing to pure PP. It is happened due to the effect of adding filler material about 30 wt% contributes to the lack of mechanical strength. The particles of the filler (CS) looked so coarse, so it contributes to the incomplete blending and meting process during hot press. As compared to previous study by Bledzki [3], it shows the tensile strength for CS/PP composite varies between 20 – 25 MPa. The tensile result was slightly different from pure PP because he used CS fiber in powder form (100-200 µm).

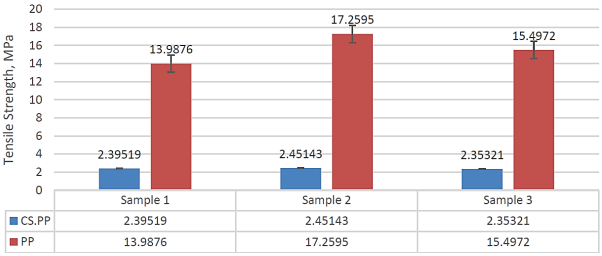

Figure 2 Tensile strength of CS/PP composite and pure PP

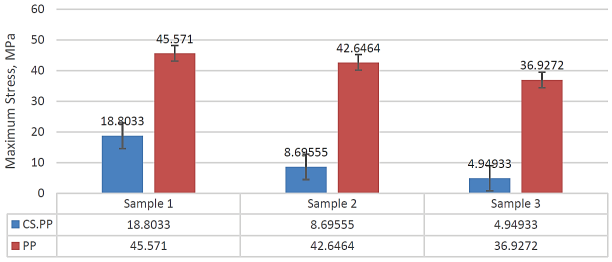

Figure 3 Flexural result of CS/PP composite and pure PP

2.1 Scanning electron microscope (SEM)

Figure 4 (a) and (b) represents the CS/PP composite and pure PP surface morphology respectively. It shows that the surface of pure PP relatively smooth while comparing to the CS/PP surface. There were some numbers of cracks, defects, void and some damage on the fiber surface. It is due to the presence of inhomogeneous size of fiber and larger particle. Hence, it shows the bonding between fiber and thermoplastic matrix was not proper. Then, in theoretically it will affect the result of the mechanical testing such as tensile and flexural strength, if there were existence of defect on surface like the pores or voids.

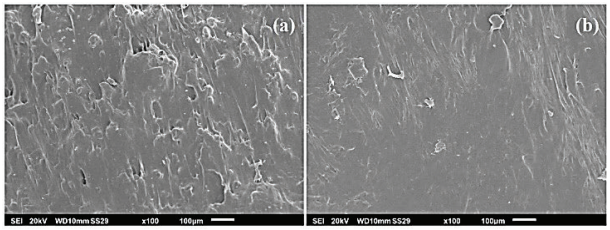

Figure 4 SEM micrograph of (a) CS/PP and (b) pure PP

4. CONCLUSION

The study explored the feasibility of utilizing of grain by-products like the coconut shell as alternative fillers as reinforcement for composites material. The CS/PP composite was thermally stable at maximum temperature of 260 degrees Celsius. It can sustain at higher temperature without decomposed while comparing to pure PP. Coconut fiber showed in homogenous compounds on the surface due to the unrefined particles. It is also affected the value of the tensile and flexural become lower. For future, it is recommended the coconut shell fiber should be in powder form as a filler in compounding process with plastic matrix.

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