EFFECTS OF ADDITIVE ON THE MECHANICAL PROPERTIES OF BAMBOO/PBS COMPOSITES

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Compared with general composites which are produced from fossil fuel, biodegradable resins have received considerable attention as an environment-friendly material. Bamboo fiber has relatively high strength compared with other natural fibers. Therefore, the focus of this study is to produce bamboo fiber reinforced Poly butylene succinate (PBS) composites by injection molding and to study the effects of additive on mechanical properties of this bamboo/PBS composite. The injection-molding is a highly productive fabrication technique. Bamboo/PBS composites were examined by flexural test and Vickers hardness. Also we examined fracture surface and microstructure of the bamboo/PBS composites by microscope.

Keywords: Green composites, Bamboo fiber, Flexural strength, Vickers hardness

1. Introduction

Natural fibers have recently attracted the attention of many researchers because of the advantages that these fibers provide over conventional reinforcement materials, and the development of natural fiber composites has been a subject of interest for the past few years. Research on the green composite, which are composed biodegradable resins and natural fibers such as ramie, hemp, pineapple, henequen and bamboo, has been carried out^{1,2}. Bamboo and kenaf has been already adopted as automobile parts, because of it has lightweight and good mechanical properties among other natural fibers. Also biodegradable resins receive considerable attention as environment-friendly material because biodegradable resins may be resolved in both water and carbon dioxide after

perfect biodegradation by the action of microorganisms². But almost of biodegradable resins have relatively low strength than typical resins such as polyethylene, it is impossible to use them as structures material. Accordingly, research on the green composite, which are composed biodegradable resins and natural fibers has been carried out. PBS is a white crystalline thermoplastic with melting point of about 90°C to 1208°C (similar to LDPE), glass transition temperature of about 45°C to 108°C (between PE and PP), tensile strength between PE and PP, and stiffness between LDPE and HDPE. PBS has excellent processing capabilities and can be processed on polyolefin processing machines at temperatures of 160°C to 2008°C, into various products, such as infected, extruded and blown ones³. Furthermore, its raw materials, butanediol and succinic acid, may be soon available from bio-based renewable resources⁴⁻⁹.

In this study, we have carried out research on effects of additive on mechanical properties of bamboo/PBS composites. By using additive with two kinds of type and two kinds of amount, bamboo fibers with 40wt.% content and the biodegradable resin (PBS 60wt.%) were produced by hot-pressing. PVA (polyvinyl alcohol) and CMC (carboxy methylcellulose) were used as an additive. PVA has excellent film forming, emulsifying, and adhesive properties. It is also resistant to oil, grease and solvent. It is odorless and nontoxic. It has high tensile strength and flexibility, as well as high oxygen and aroma barrier properties. However these properties are dependent on humidity, in other words, with higher humidity more water is absorbed. The water, which acts as a plasticiser, will then reduce its tensile strength, but increase its elongation and tear strength. PVA is fully degradable and is a quick dissolver. CMC is a cellulose derivative with carboxymethyl groups (-CH₂-COOH) bound to some of the hydroxyl groups of the glucopyranose monomers that make up the cellulose backbone. It is often used as its sodium salt, sodium carboxymethyl cellulose.

2. Experiment

2.1. Sample Preparation

Bamboo/PBS composites were fabricated, using a length -250μm to +500μm short bamboo fiber that were dried for 24 hour at 105°C with a fiber content of 40.wt%. Where (-) means that fibers passed through the mesh, and (+) means that fibers were retained on the mesh. The bamboo fibers were used as received conditions without any surface treatment. The PBS (polybutylene succinate) resin (Showa Highpolymer Co., Ltd., Japan) was used as a matrix resin. The additives were used PVA and CMC (12.5g and 25g respectively). Bamboo fiber and PBS were thrown into an extruder (TITAN45, Cincinnati Extrusion GmbH, Austria) to make bamboo/PBS pellets. The bamboo/PBS pellets was hot-pressed under a pressure of 10MPa at 130°C for 4min.

2.2. Measurement of mechanical properties and Surface characterization

The flexural strength was measured using a 3-point bending tests using a universal testing machine with a specimen size of 50mm×3.8mm×5mm, crosshead speed of 0.5 mm/min and a span length of 30mm at room temperature, using the four specimens.

Vickers hardness of bamboo/PBS composite was investigated by using a Mitutoyo Hardness testing machine. We also observed the fracture surface of bamboo/PBS composite after 3-point bending tests by field emission scanning electron microscopy (FE-SEM).

3. Experimental Results and Discussion

Fig. 1 (a) shows the flexural strength from 3-point bending test of the bamboo/PBS composite using without additive, CMC 12.5g and CMC 25g. Without additive bamboo/PBS composites possessed an average flexural strength of about 42.87MPa, which lower than that CMC 12.5g (about 44.05MPa). Fig. 1 (b) shows the flexural strength of bamboo/PBS composites using PVA (without additive, 12.5g and 25g). The result showed 44.08MPa at PVA 12.5g, the minimum value of 35.24MPa at PVA 25g. Fig. 2 shows the fracture surface of bamboo/PBS composites without additive, CMC 12.5g and PVA 12.5g. In the case of bamboo/PBS composites without additive, it can be seen from this figure that there is many pull-outed fiber on the fracture surface, which is indicating weak adhesion between bamboo fiber and PBS resin. However we can be seen less pull-outed fiber and sticky case of CMC 12.5g and PVA 12.5g. Therefore, bamboo/PBS composites with CMC 12.5g and PVA 12.5g shows higher than flexural strength of without additive.

Fig. 1 Effect of additive on flexural strength of bamboo/PBS composites

Fig. 2 Fracture surface of bamboo/PBS composites after 3-point bending test

The effect of additive on Vickers hardness of bamboo/PBS composites are shown in Fig. 3. In case of used CMC additive, the maximum value of 35.1HV of CMC 12.5g (Fig. 3(a)). Fig. 3(b) showed Vickers hardness of bamboo/PBS composites used PVA additive. It can be seen highest Vickers hardness value case of 12.5g.

Fig. 3 Effect of additive on Vickers hardness of bamboo/PBS composites

4. Conclusions

In this study, we fabricated bamboo fiber reinforced PBS composites with additive, and evaluated their mechanical properties such as flexural strength, Vickers hardness. The results obtained are summarized as follows,

- (1) The effect of additive on flexural strength showed 42.87MPa at without additive, 44.05MPa at CMC 12.5g and 32.19MPa at CMC 25g. In case of PVA additive, that showed 42.87MPa at without additive, 44.08MPa at 12.5g and 35.24MPa at 25g.
- (2) The fracture surface of the bamboo/PBS composites with additive CMC 12.5g and PVA 12.5 showed less pull-out fiber and sticky. Therefore, bamboo/PBS composites with CMC 12.5g and PVA 12.5g shows higher than flexural strength of without additive.
- (3) In case of used CMC additive, the maximum value of 35.1HV of CMC 12.5g. Vickers hardness of bamboo/PBS composites used PVA additive. It can be seen highest value at 30.96HV case of PVA12.5g.

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