Manufacturing Technique and Property Evaluation of Impact-Resistant Polypropylene/ Glass Fiber Composites

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Key words: polypropylene, glass fibers, IZOD impact strength

Abstract

Using the injection molding method, impact-resistant polypropylene (PP) and glass fibers (GF) with weight ratios of 5 wt%, 10 wt%, 15 wt%, 20 wt%, 25 wt% and 30 wt% were blended twice, completing high-impact PP/ GF composites. Next, the tensile strength test, flexural stress test and IZOD impact strength test measured the composites. According to the results, with an increase in glass fibers, the composites exhibited a greater tensile strength, which further reached to climax when the GF weight ratio was 25 wt%. However, tensile strength appeared inversely proportionate to the blending frequency. In addition, regardless of blending frequencies, the optimum flexural stress occurred when the GF weight ratio was 25 wt%; nevertheless, it started declining when the ratio was 30 wt%. Finally, indicated by IZOD impact test, the greater the GF weight ratio, the lower the impact strength the composites exited.

Introduction

With the increasing in population in the world for the past few years, and residential areas for mankind have been decreasing relatively, high buildings are the only solution nowadays. However, earthquakes occurred one after another around the world. It not only caused buildings to topple, but also imposed great threats upon the lives and properties of the human beings. Reinforced concrete has always been the major building structure. To prevent cracks growing on the concrete surface is the way that several works have attempted. For example, blend the filaments or staples into the concrete. Redon Carl et al. studied reinforced concrete with iron fiber and effectively prevented cracks increasing[1]. Sydney Furlan Jr. et al. studied the concrete reinforced with steel and PP fibers, and the result showed that the reinforced mechanism of fibers in concrete just like with stirrups[2]. Jin-Kyung Lee et al. investigated carbon fiber sheet reinforced concrete, and the result reveal that it could remarkably decrease the crack initiation and propagation[3]. After surveying, the literatures, we found many researchers have paid attention to reinforcing the concrete with fiber materials which belong to "one-dimension linear reinforcement". In this work, a grid (a netlike structure) was produced to reinforce the concrete for the purpose of "two-dimension plane reinforcement". In recent years**,** there has been an increasing trend in the use of glass fiber-polypropylene composite systems in semi-structural and engineering applications. These thermoplastic matrix composite systems process with their property advantages of enhancing composites' toughness and gaining an unlimited shelf life. Furthermore, their intrinsic recyclability is rapidly being recognized as a strong driving force for their further application [4]. Single polymer application cannot satisfy the contemporary needs and it is a trend to add proper additives or reinforcing agent.

Blending process subsequently becomes the major method to modify the composites by reducing the uneven mixture in the polymer manufacture [5]. In response to assorted requests by property modification, there is a variety of polymer manufacturing. Mechanical properties, chemical properties, surface glossiness, and composite homogeneity of materials are all highly correlated, which are responsible for evenly-mixed composite**s**.

PP is the most pervasive material used widely in the plastic fields, which is categorized into general level, high impact level, transparent level, high crystallinity level and special specifications level[6-7]. Industrial-grade functional textiles are the one of the major productive goals for textile industry in the application fields. From 2010, Lin et al. have utilized fiber materials in fiber composite[8-14]. High impact level refers to single polymer added with ethylene polypropylene rubber, whose impact strength depends on the rubber content, and cold level counts on the ethylene. Impact-resistant polypropylene possesses good heat resistance, water proof, and electrical insulation and chemical properties**;** and does not interact with most chemical products except for strong oxidant.

Likewise, glass fiber is one of the most available high-end modern materials for industrial construction, possessing qualities like light weight, heat stability, electrical insulation, chemical stability, and high tenacity. As it is eco-friendly, glass fiber has been extensively used in sports outfits, channels, boats, cars, casings of electronic products, and printed circuit boards, etc.

Experimental

Impact-resistant PP (MFI: 3 g/10 min of K8003) is offered by Formosa Chemical & Fiber Corporation) while glass fibers (Cord 202P 3.2 SP28112193006) by Taiwan Glass Ind.). Impact-resistant PP was premixed with GF with ratios of 5 wt%, 10 wt%, 15 wt%, 20 wt%, 25 wt%, and 30 wt%, and then mixed two times using a single-screw extruder with settings: die temperature was 240 ℃,barrel temperature was 220 ℃and screw speed was 10 rpm. Next, the impact-resistant PP/ GF chips derived from the first blending were dried in the oven at a temperature of 50 ℃ for 24 hours before the second blending.

Firstly, following the injection molding process, the composites were evaluated with the tensile strength in accordance with ASTM-D638. The injection samples had to be prepared and tested five times based on ASTM-618 (the plastic specimens regulations) with settings: specimens of injection were preserved at temperature of 23±2 ℃ and relative humidity of 50±5 % for over 40 hours; the length of the upper and lower holders of the mold was both 2 mm; sample size was 80x12.85x3.2 mm^3, test speed was 1.3 mm/ min and the extension speed was 5 mm/ min. Secondly, in accordance with ASTM-D790, the flexural stress test measured the samples, which also fulfilled the requirements and treatments by ASTM-618. Finally, the impact strength test was employed five times based on ASTM-D256 with following settings: samples were with V-shaped notch whose depth was 0.25 R±0.5 mm and the specimens' size was 63.5x12.85x3.2 mm^3.

Results and Discussion

Figure 1 reveals that tensile strength of the impact-resistant PP/GF is proportionate to glass fibers' content but inversely proportional to the blending frequency. The maximum tensile strength of 2502.41 N occurred when the glass fiber was 25 wt%, and the blending frequency is one time. In contrast, the minimum tensile strength of 1167.094 N occurred when the glass fiber was at 5 wt% and blending frequency was two times.

Noticeably, when glass fiber exceeded 30 wt%, the composites exhibited a declining tensile strength. Additionally, with blending frequency, the molecule chain of the PP/ GF composites were heat-decayed, decreasing the tensile strength accordingly.

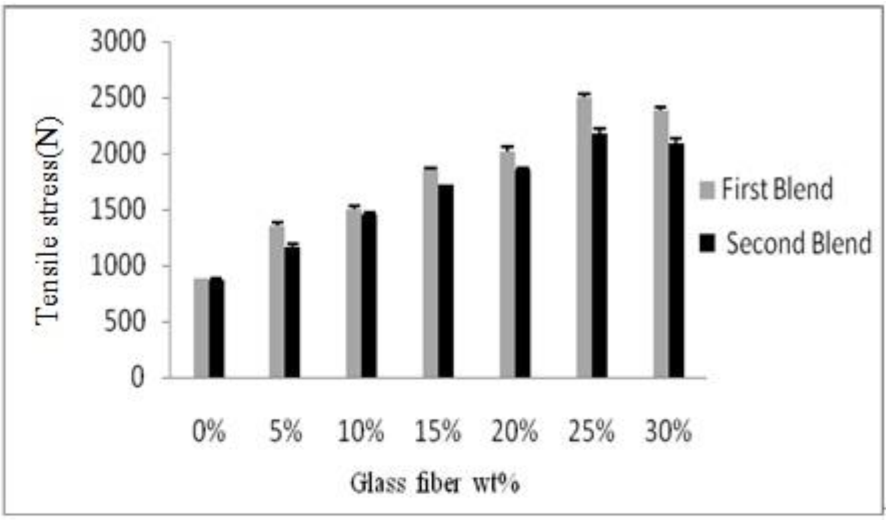

Figure 1 The tensile strength of the impact-resistant PP/ GF composites with different blending frequencies.

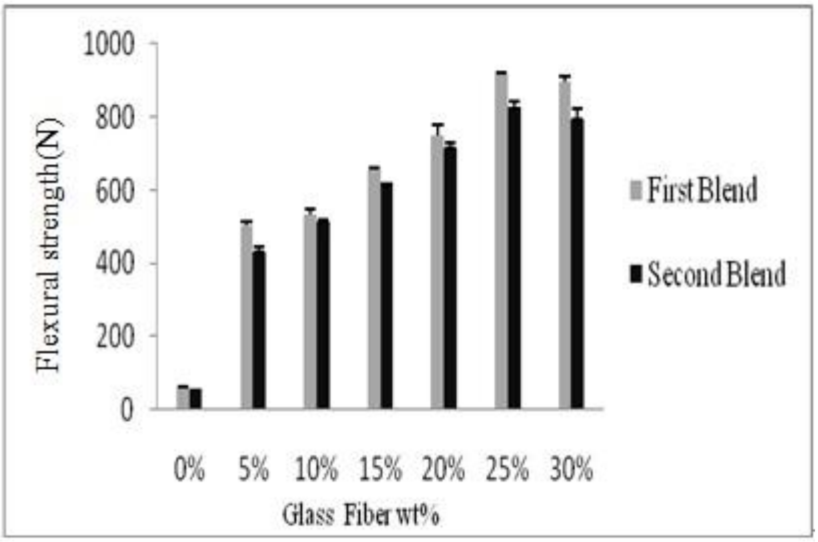

Figure 2 The flexural stress of the impact-resistant PP/ GF composites with different blending frequencies

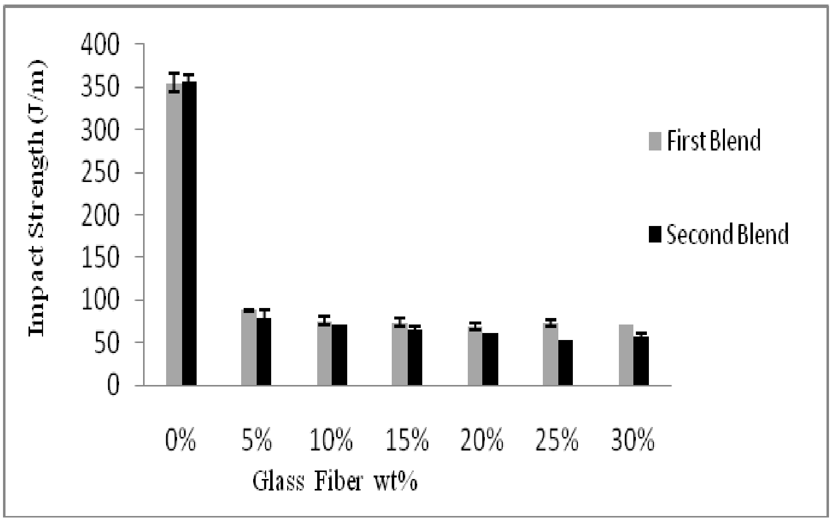

Figure 3 The IZOD impact strength of the impact-resistant PP/ GF composites with different blending frquency.

Figure 2 shows that flexural stress of the impact-resistant PP/ GF composites increases with the increase in glass fibers' content, preventing the composites from deforming. Like tensile strength, flexural stress was also inversely proportionate to the blending frequency. The optimum flexural stress of 916.142 MPa occurred when glass fiber was at 25 wt% and the PP/ GF composites were blended for one time, while the minimum flexural stress of 431.484 MPa occurred when the glass fiber was 5 wt% and the PP/ GF composites were blended for one time. The molecule chain was heat-decayed with the blending frequency, which was ascribed to a decrease in flexural stress.

Based on Figure 3, the impact strength of the impact-resistant PP/ GF composites decreases with an increase in glass fibers, as the greater the glass fibers' content, the more brittle the PP/GF composites. Glass fibers had properties like great brittleness and inferior tenderness, which were responsible for the lower impact strength of the composites. The addition of glass fibers in the PP/ GF composites did not reinforce but deteriorate the impact strength of the IRPP/ GF composites. The greater the glass fibers' content, the lower the impact strength. Furthermore, the impact strength also decreased with the blending frequency due to the heat-decayed molecule chain in the composites.

Conclusions

In this study, we manufactured the impact-resistant PP/GF composites successfully. These composites contain different content of glass fibers and the raw materials were blended different times. The tensile strength test, flexural strength test, and IZOD impact strength test were employed to measure the mechanical properties of the composites. With the addition of glass fiber of 5 wt% to 30 wt%, the tensile strength of the IR PP/ GF composites increased, flexural strength increased, but impact strength decreased. According to the results of this research, a weight ratio of glass fibers was 25 wt% and blending frequency was one time were concluded as the optimum manufacturing parameters for producing impact-resistant PP/ GF composites.

Acknowledgement

This work would especially like to thank National Science Council of the Republic of China, Taiwan, for financially supporting this research under Contract NSC 99-2622-E-035-008-CC3.

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