Study on the Preparation and Properties of $CaCO_3$/Polypropylene Composite Materials

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Abstract: According to the mechanical defects of polypropylene (PP), we blended modification of PP with calcium carbonate ($CaCO_3$). We used the blends of $CaCO_3$ and PP as the research object to test the mechanical properties of CaCO3/PP composite materials with different proportions and studied the influence that $CaCO_3$'s content have on the mechanical properties of the composites. During the experiment, the twin screw machine and injection molding machine were used to prepare the sample of composite materials with different ratios. Then, a test had been started on the mechanical properties of composite materials. Based on the analysis of the experimental data, the results show that it can improve the impact strength under certain conditions when adding $CaCO_3$ into PP. But, the function of tensile strength, elongation and yield strength will decrease. When the content of $CaCO_3$ is 10% it shows better comprehensive mechanical properties. The numerical of the impact strength, the tensile strength, the yield strength and the elongation at break is 66.47kJ/m2, 11.28MPa, 9.37MPa and 873.8%. With the increase of $CaCO_3$ content, the mechanical properties of $CaCO_3$/PP composites will get worse.

Introduction

PP is a kind of polymer material with very strong plasticity[1]. But because of its poor ability to resist impact strength and serious sensitivity to the gap[2], it can not meet the needs of our daily production. The shortage of raw materials in China also leads to the increase of the price of PP.

The composite material is a new material, which is formed by two or more than two kinds of material or artificial synthesis. The two main types of materials can be classified into functional composite materials and structural composite materials. Composite materials commonly used have a variety of fiber, metal wire and inorganic rigid particles, etc. Blending modification can improve the physical and mechanical properties, transparency, coloring, antistatic property, and can reduce the production cost [3].

In this paper, an inorganic filler $CaCO_3$ was modified to improve the mechanical properties of PP and reduce the production cost[4-5]. We tried to get a best blended proportion of PP and $CaCO_3$ through investigation on the impact strength, the tensile strength, the yield strength and the elongation at break of the $CaCO_3$/PP composite materials with different ratios.

Experimental section

1 Kg of blended materials of $CaCO_3$/PP were accurately weighed and the ratio of mass fraction of $CaCO_3$ is 0%, 5%, 10%, 15%, 20%, 25% and 30%, respectively. Table 1 lists the material used in the experiment and their specifications. The blended particles were processed in the injection

molding machine and five of impact and tensile splines of each group which meet the standard of GT/T 1043.1-2008 were prepared. Tensile and impact tests were carried out with the electronic universal mechanical testing machine and impact test machine with a simply supported beam.

Table 1 Materials and their specifications

Materials	Specifications
PP	PPH-T03
$CaCO_3$	800 mesh

Results and discussion

Through the blending modification experiment, we found that the different proportion of $CaCO_3$ has great influence on the mechanical properties of the blends. Table 2 exhibits the total data of the effect of $CaCO_3$ content on the mechanical properties of $CaCO_3$/PP composites materials.

Table 2 The total data of the effect of $CaCO_3$ content on the mechanical properties

Content (%)	0	5	10	15	20	25	30
Impact strength (au kJ/m^2)	8.94	66.81	66.47	6.84	7.23	7.90	7.19
Tensile strength (MPa)	31.92	11.26	11.28	22.16	26.32	26.87	26.03
Yield strength (MPa)	31.75	7.22	9.37	22.16	26.22	26.87	26.03
Elongation at break (%)	1162.8	805.1	873.8	35.26	47.40	59.20	89.02

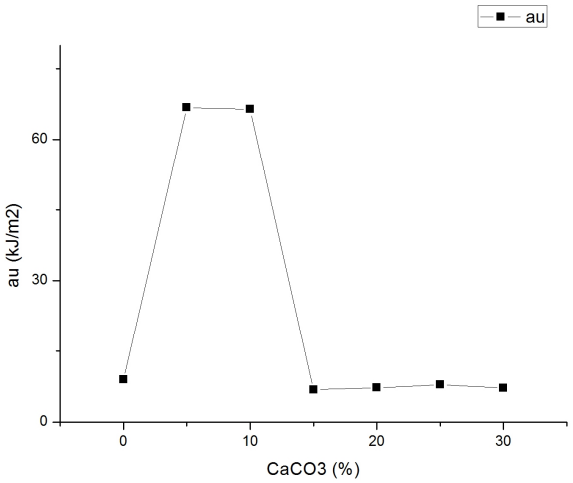

Figure 1 Effect of the content of $CaCO_3$ on the notched impact strength of $CaCO_3$/PP composites

Seeing from figure 1, the impact strength of $CaCO_3$/PP composites increases with the increase of the content of $CaCO_3$, and it is the largest when the content is 5%-10%. After the addition of a small amount of $CaCO_3$, the impact strength of PP has been greatly improved. But when the content of $CaCO_3$ was over 10%, the impact strength of the composite was sharply decreased, and the impact strength of the composite keep in low level.

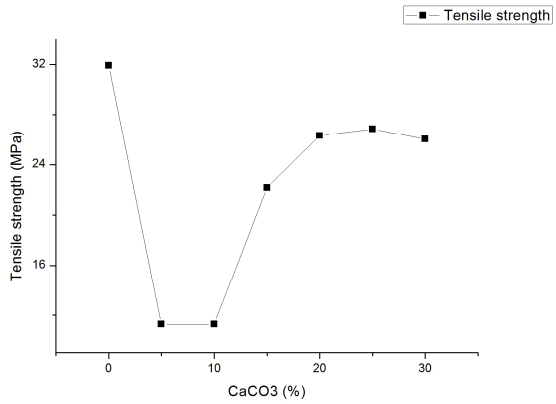

Figure 2 Effect of the content of $CaCO_3$ on the tensile strength of $CaCO_3$/PP composites

From figure 2 it can be seen that the tensile strength of $CaCO_3$/PP composites decreases with the increase of the content of the $CaCO_3$, and then is in the trend of increase. But lastly the tensile strength gradually becomes small. When the content of $CaCO_3$ is 5%-10%, PP tensile strength decreases rapidly. Without $CaCO_3$, the tensile strength of the composite material is the strongest.

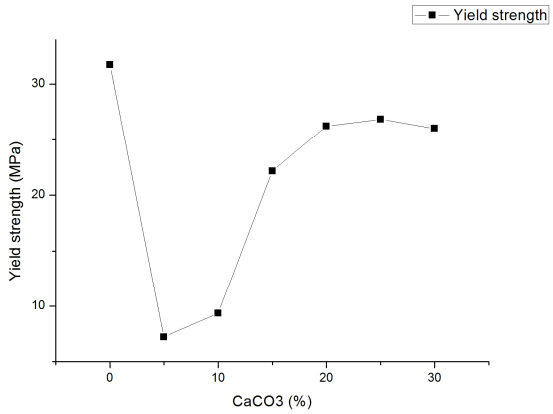

Figure 3 Effect of the content of $CaCO_3$ on the yield strength of $CaCO_3$/PP composites

We may discover from figure 3 that the yield strength of the composite increased and then decreased with the increase of the content of the $CaCO_3$. When the content of $CaCO_3$ is 5%, the yield strength of the composite is lowest. Then, with the increase of the $CaCO_3$, the yield strength gradually becomes larger. The yield strength reached the maximum when the content of $CaCO_3$ is about 25% but still lower than without addition of $CaCO_3$.

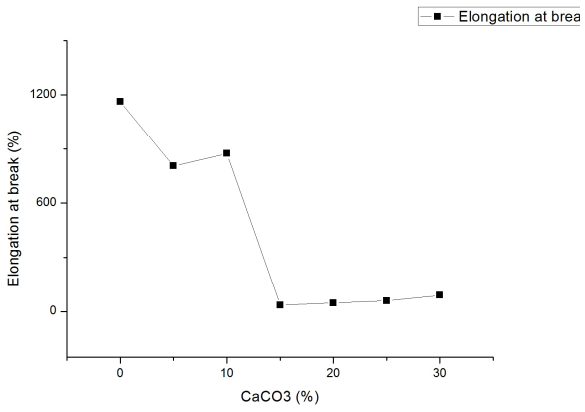

Figure 4 Effect of the content of $CaCO_3$ on the elongation at break of $CaCO_3$/PP composites

From Figure 4 we can find that the elongation at break of $CaCO_3$/PP composites decreases with the increase of the content of $CaCO_3$ on the whole except for a small increase in range of 5%-10% and 15%-30%. When the content of $CaCO_3$ is 15%, the elongation at break of the composite reached the lowest point. But the overall performance was not good, and it is easy to break.

From all the above results we can see the toughness PP was greatly improved by the use of $CaCO_3$, but the tensile properties decreased and the strength of the materials decreased. So it is not possible to add too much $CaCO_3$. This may be due to the excessive accumulation of inorganic particles of $CaCO_3$ result in the change of internal structure of the composite material, which makes the composite material have a poor mechanical properties.

Conclusions

Through this experiment, we can find that the influence of $CaCO_3$ on PP is indeed a toughening effect. When the content of $CaCO_3$ is about 10%, the mechanical properties of $CaCO_3$/PP composites are the best. But with the increasing of the content of $CaCO_3$, the mechanical properties of the composites are all decreased. This study provides a theoretical support for the modification of PP, which can provide help to the industrial production and reduce the cost of production. But we should use $CaCO_3$ according to the actual situation. We can not blindly pursue the cost and should find a balance between the cost and the performance.

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