

Tough and Reinforced Polypropylene/Kaolin Composites using Modified Kaolin

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Abstract: Polypropylene (PP)/kaolin composites have been prepared by filling modified kaolin with diethylenetriaminepentaacetic acid (DTPA) into the PP matrix. The surface modification of kaolin particles effectively improves the compatibility between kaolin and PP matrix. It is conducive for uniform dispersion of inorganic particles in the matrix, and enhances the mechanical performance of the composites. Compared with plain kaolin, the mechanical properties of the modified composites exhibit higher tensile strength, bending strength, impact strength and melt index simultaneously. The DTPA modification of kaolin overall enhances the mechanical properties of PP composites. It meets the requirements in various applications, and makes the modified experiment interesting in modern teaching.

1. Introduction

Polypropylene (PP) is one of the most important commercial thermoplastics because of relatively low cost, versatility, and recyclability good mechanical performance. However, its application is limited as an engineering thermoplastic polymer because of the relatively poor impact resistance and stiffness^[1].

In order to improve the mechanical properties of polypropylene (PP), various polymer blends have been fabricated by adding different fillers^[2] in PP matrix, and some toughening mechanisms have been investigated in past years. However, there is poor interfacial adhesion between the PP matrix and filler which usually results in decreased toughness. The usual incompatibility between the thermoplastic and the filler, which leads to large size of the dispersed phase inadequate for toughening, and is usually overcome by chemical modification of the filler^[3-9].

In this study, PP has been mixed with kaolin modified with diethylenetriaminepentaacetic acid using conventional teaching experiment method. The phase behavior of the blends was studied by FTIR, and



the mechanical behavior was studied by means of tensile, bending, impact and melt index test experiments, which make the classic experiment more interesting in modern teaching..

2. Experimental

2.1. Materials

Polypropylene (PP), supplied by China Dushanzi Petrochemical Limited Branch

Kaolin, supplied by FoshanYufeng Powder Co., Ltd

Diethylenetriaminepentaacetic acid (DTPA), supplied by Sinopharm Group Chemical Reagent Co., Ltd.

2.2. Preparation of modified kaolin

The kaolin, DTPA and alcohol were added into a three-neck flask agitated for 30min. Subsequently, the product was dried at room temperature.

2.3. Preparation of composites

The modified kaolin was melt-blended with PP in twin-screw extruder. And the blends were injection molded into ultimate composites standard bars for mechanical test with injection molding machine.

2.4. Mechanical test

Tensile bending impact and melt index test were conducted. For each test and type of composite, ten specimens were tested and the average values are reported.

3. Result and discussion

3.1. Tensile strength

The tensile data of the PP/kaolin composites (kaolin content are respectively 0, 10, 20, 30, 40, 50 wt%) is shown in Fig. 1. It can be seen that kaolin fillers increased the tensile strength of the composite in low content, but then led to decrease in the tensile strength when the fillers contents reached 20 wt%. Above 20 wt% there is no further increase in the tensile strength.

In comparison with composites filled by kaolin and modified kaolin, all of the composites filled by modified kaolin show higher tensile strength.

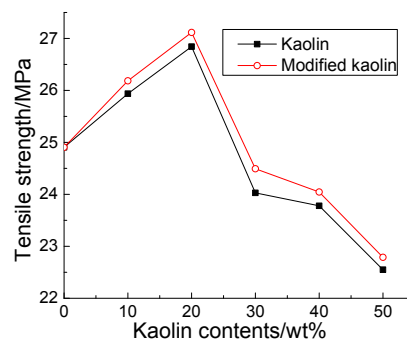


Figure 1. Effect on the tensile strength of the PP/kaolin for increasing wt% kaolin

3.2. Bending property

The bending properties of PP/kaolin composites with varying amount of kaolin are shown in Fig. 2a

and Fig.2b. It can be seen that kaolin fillers can increased the bending strength of the composites in the lower loading region, but then led to decrease in the bending strength when the fillers contents reached 20 wt%. Above 20wt%there is no further increase of bending strength. And the bending modulus of the composites increases with the kaolin content.

The rule of composites filled by modified kaolin is similar with that of it filled by unmodified kaolin, and the bending strength of all the composites filled by modified kaolin are higher than that of the composites filled by the unmodified kaolin.

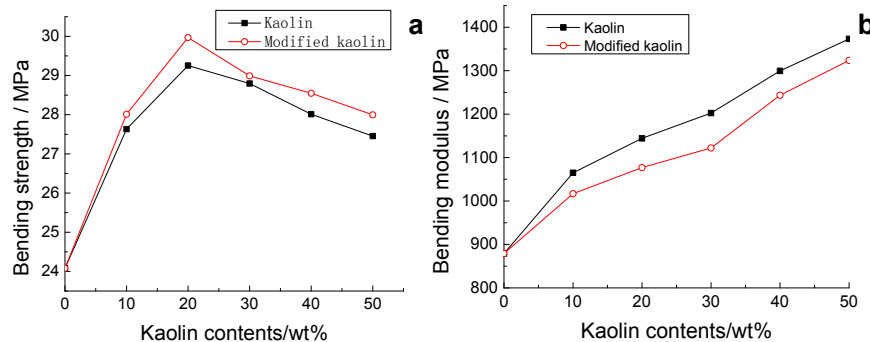


Figure 2 Effect on the bending properties of the PP/kaolin for increasing wt%kaolin

3.3. Impact strength

Fig. 3 shows the impact strength of PP/kaolin composites as a function of kaolin content. The impact strength decreases with addition of kaolin. The kaolin is inorganic rigid with high surface energy. When mixed with the hydrophobic PP, the agglomeration of kaolin particles became serious, and the interfacial adhesion of kaolin particles and PP matrix is small, which becomes the weak point of composite materials. The addition of rigid particles limited the movement of the PP macromolecule chains, weakening the ability to cope with external forces, resulting in an increase in the brittleness of the composites^[10]. It led to the impact strength of composites decrease from 9.4 kJ/m² to 7.0 kJ/m².

Research on the composites filled by modified kaolin, the addition of modified kaolin led the impact strength increase at first and decreases subsequently, which show that the impact strength of the materials has been greatly improved by surface modification.

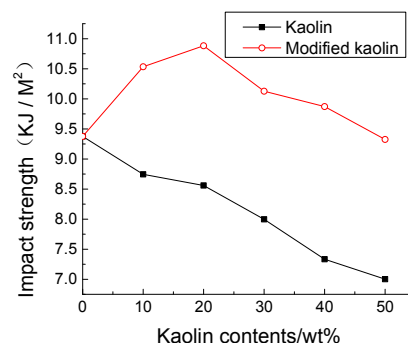


Figure 3 Effect on the impact strength of the PP/kaolin for increasing wt% kaolin

3.4. Melt index

Fig.4 shows the melt index of PP/kaolin composites with varying amount of kaolin. The melt index decrease with addition of kaolin. During the process of shear dispersion, kaolin particles tend to

agglomerate and form larger particles. When the shear flow occurs, the collision and friction between particles produce flow resistance, which leads to the decrease of system mobility.

After the surface modification, the effect on melt index of composites was decrease. The melt indexes of all composites filled by modified kaolin are higher than that of composites filled by unmodified kaolin.

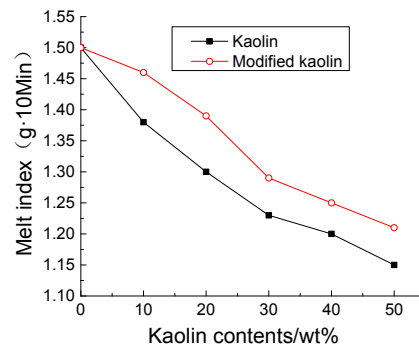


Figure 4 Effect on the melt index of the PP/kaolin for increasing wt%kaolin

3.5. FTIR

From the curves of Fig.5, in modified kaolin the peak at 1792cm^{-1} is the absorption peak of C=O. absorption peaks at 1402cm^{-1} is smaller and deeper due to the stretching vibration of C-N bond. The absorption peak at 866cm^{-1} is the out of plane bending vibration of O-H bond in carboxylic acid, the absorption peak at 710cm^{-1} is the plane bending vibration of N-H bond, suggesting the exist of amido and carboxyl. It demonstrated that composites contains DTPA

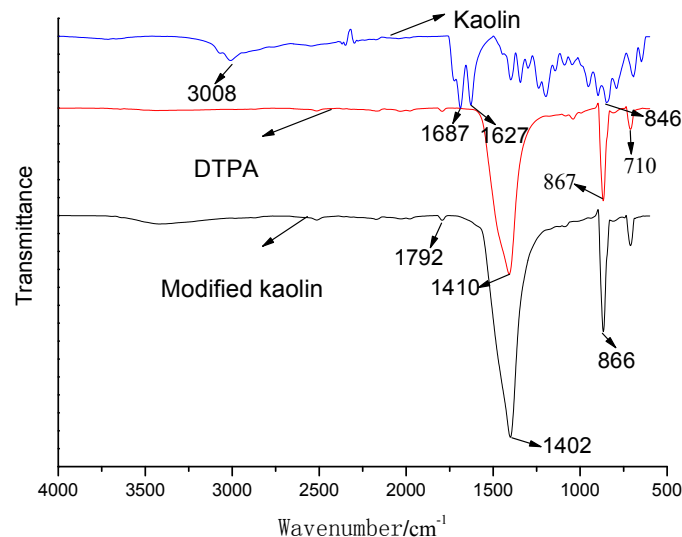


Figure 5 FTIR spectra of kaolin and modified kaolin

4. Conclusion

The PP/kaolin composites showed higher tensile strength, bending strength, impact strength and melt index. When the content of modified kaolin is 20wt%, the composite has the best mechanical. Comparing the tensile strength, bending strength, impact strength and melt index of the composites filled by 20wt% modified kaolin and 20wt% unmodified kaolin, the tensile strength was increased from 26.8MPa to 27.1MPa, the bending strength was increased from 29.2MPa to 29.9MPa, the impact

strength was increased from 8.5kJ/m² to 10.9kJ/m² and the melt index was increased from 1.30g/10min to 1.39g/10min. So, the conventional modification method of kaolin improved the compatibility of PP and kaolin, and tough the composites. The composite filled by DTPA modified kaolin can fully meet the demand of automotive, home appliances, construction, machinery and other areas.

Acknowledgments

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