Improvement of mechanical properties for transparent polymer materials by additives

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Glassy amorphous polymer materials such as polycarbonate (PC), poly(methyl methacrylate) (PMMA) and polystyrene (PS) are widely employed in industrial fields due to their good transparency and mechanical properties. In particular, PC is expected as a substitution of inorganic glasses because of its excellent mechanical toughness and heat resistance property. However, its modulus and surface hardness in the solid state and flowability in the molten state, i.e., processability, are not good enough to widen its application.

In this study, the disadvantages of PC are improved by the addition of different materials without losing its transparency. The thesis is composed of the following chapters.

Chapter 1 General introduction

Chapter 2 Miscibility and segregation behavior under temperature gradient of PC/PMMA blends

A new method to produce concentration gradient in the miscible PC blend was demonstrated. The blend of PC and low-molecular-weight PMMA, which are found to be miscible, was used in this study. After annealing the PC/PMMA blend in a temperature gradient, PMMA localized on the high temperature side. This phenomenon is notable because it is applicable to enhance the anti-scratch properties of PC.

Chapter 3 Surface segregation of PMMA during injection-molding of PC/PMMA blends

The distribution of the constituent polymers in an injection-molded product comprising a miscible blend of PC and low-molecular-weight PMMA was studied. It was found that PMMA is localized at the surface without affecting the transparency of the product. As a result, the surface hardness was effectively enhanced by a small amount of PMMA. This technique can be used to produce an ideal plastic glass that has high transparency, mechanical toughness, and high surface hardness.

Chapter 4 Modulus enhancement of PC by addition of lithium perchlorate

The mechanical properties of PC containing lithium perchlorate ($LiClO_4$), which is found to ionize in PC, were examined. The modulus of PC was greatly enhanced by the addition of $LiClO_4$ because of the electrostatic interaction between the lithium cation and the carbonyl group in PC molecules. The addition of $LiClO_4$ does not sacrifice the advantages of PC, such as heat resistance, transparency, and mechanical toughness.

Chapter 5 Flowability enhancement of PC by addition of PS

The shear viscosity of binary blends comprising PC and low-molecular-weight PS (L-PS) was examined. It was found that the viscosity of PC significantly decreases by the addition of L-PS. Although the dynamic mechanical properties indicated that L-PS is immiscible with PC, the morphology observation of the extruded strand clarified that shear-induced phase-mixing occurs. Furthermore, the viscosity decrease was found to be pronounced in the high shear stress condition. The addition of L-PS can improve the flowability at injection-molding of PC greatly.

Chapter 6 General conclusion

Key words

Polycarbonate, Polymer blend, Miscibility, Segregation, Flowability