Modification of amorphous polymers by the addition of antipalsticizers

Polycarbonate (PC) is widely employed in optical applications such as plastic glasses, optical disks, and optical films because of its excellent transparency, mechanical toughness, and good cost-performance. In the field of optical films, one of the most important applications for PC is a retardation film. It is well known that a retardation film is indispensable to improve the color contrast and viewing angle of liquid crystal display (LCD) and is needed for electro-luminescence display to prevent the reflection of ambient light. Recent target for retardation films is to reduce their thickness to prepare a thin display. Since the retardation is determined by the product of the thickness and orientation birefringence, it is necessary to enhance the orientation birefringence. Furthermore, it is also required to increase the Young's modulus to keep the rigidity of the film. Another serious requirement is to reduce the photoelastic birefringence in the glassy state. As well known, thermal expansion of a film, leading to stress generation in a display, is responsible for the unnecessary birefringence which should be minimized. Therefore, thermal expansion coefficient and stress-optical coefficient are required to decrease. One of the methods to enhance the modulus without losing the transparency is to add an antiplasticizer. Some compounds are known to enhance the modulus by the reduction of the free volume, which is so called the antiplasticization. Moreover, the free volume filling effect is expected to reduce the thrmal expansion coefficient. In this study, mechanical, optical, and thermal properties are investigated for the blends of PC with *p*-terphenyl (*p*-tPh).

A small addition of *p*-tPh enhances the modulus in the glassy state, demonstrating that it acts as an antiplasticizer for PC. The modulus increases monotonically with increasing *p* -tPh and seems to reach a plateau value beyond 10 wt%. The result indicates that the filling effect of free volume is saturated around 10 wt% of *p*-tPh. The orientation birefringence is greatly enhanced by the p-tPh addition, even the stretching is performed at the same stress level, i.e., the same degree of PC orientation. This is attributed to the orientation of *p*-tPh molecules due to the intermolecular orientation correlation, known as the nematic interaction. It is also found that stress-optical coefficient in the glassy state for PC is reduced by the addition of *p*-tPh. This seems to be owing to the modulus enhancement. Thermal expansion in the glassy state is found to be reduced by the *p*-tPh addition. This result is attributed to the low level of free volume fraction. It is interesting to note that the thermal expansion coefficient of the blend with 10 wt% of *p*-tPh is almost identical to that of PC/*p*-tPh (5 wt%), i.e., a similar trend to the enhancement of the modulus at room temperature.

Because the blend with *p*-tPh shows high level of orientation birefringence as well as high modulus at room temperature, it can be used to reduce the thickness of a retardation film for LCD. Moreover, the reduced thermal expansion coefficient and stress-optical coefficient of PC/*p*-tPh indicate that the unnecessary birefringence decreases even at high temperature.

Keywords: amorphous polymer; antiplasticization; mechanical properties; optical properties; thermal properties