Phenomena Study of Polymer Blend between Polycarbonate and Polycarbonate Oligomers

Sommai Pivsa-Art[1], Chavalit Sangswasd[1], Weerasak Moocharoen[1], Kullanai Tritreungsakul[1], Yukinobu Murakami[2], Machiko Mizoguchi[3], Hiroyuki Hamada[3]

Abstract:

This paper presents a study on distribution phenomena of polymer blends between Polycarbonate Oligomer (PC Oligomer) and Polycarbonate (PC) with different oligomer contents and fabrication conditions. The samples were prepared in CD form by injection molding and were then cut into 6 pieces with varies distance from its gate. Consequently, each cut samples was sliced with thickness of 100, 400 and 200 μm from its surface, respectively. The sliced samples were subjected to differential scanning calorimeter (DSC) analysis to confirm the oligomer contents distribution. It was found that both oligomer constitutions and injection conditions have significant influenced on the phenomena of injection products. The studied results are valuable for application to plastic industries.

Keywords: Polymer Blend, Polycarbonates, Polycarbonate oligomer, Injection molding, Molecular weight

1. INTRODUCTION

Polycarbonate is one of the most important commercially engineering plastics. This kind of polymers exhibits excellent mechanical properties such as good toughness and high impact strength as well as high resistance to corrosion and deformation due to environmental conditions. The polymers are transparent and good electrical resistance. They are widely used as car windshield, electrical appliance, helmet, compact disc, etc.

One of the drawbacks of polycarbonate application is the low glossy feature on surface of the fabricated products. In manufacturing, the finishing processes after injection molding of polycarbonate fabrication by vanishing and coating with glossary materials is needed. These will results in significant time and process consume.

With these backgrounds, we have studied the alternative methods of polycarbonate injection molding by blending of polycarbonate with polycarbonate oligomers. By appropriate injection condition, the polycarbonate oligomers may diffuse to the surface of the molding products during

1 Department of Materials and Metallurgical Engineering, Faculty of Engineering, Rajamangala Institute of Technology, Klong 6, Thanya-buri, Pathumthani, 12110, Thailand

2 Mitsubishi Engineering-Plastics Corporation Technical Center Asia Ltd., 700/458, Moo 7, Amata Nakorn Ind. Estate, T. Donhuaroh, A. Muang, Chonburi, 20000, Thailand

3 Department of Advanced Fibro Science, Kyoto Institute of Technology (KIT), Matsugasaki, Sakyo-ku, Kyoto, 606-8585, Japan

processing. In this study, the behavior of polycarbonate oligomers with various injection conditions was investigated.

2. METHODOLOGY

2.1 Materials, Fabrication Process And Mechanical Tests

Polycarbonate (PC) (Jupilon S-3000) and polycarbonate oligomers; Mitsubishi Engineering-Plastics Co., Ltd.). The resins were dry blended at a weight ratio of 95:5 and 80:20 and compounded using a twin screw extruder. The blend was then injection molded using a Sumitomo SD-40 α injection molding machine at 350-370°C barrel temperature,80-100°C mold temperature and 60, 120 and 200 mm/sec injection speed to give 11 compact disc samples (Table 1). The injection molded products were cut into 3 pieces with 8 × 38 mm. and then divided into 6 equal sections and cut to give samples of dimension 6 × 8 mm. which results in 18 samples for each injection conditions. The samples were attached to the holder using dichloromethane as solvent cement (Fig. 1) and were then sliced using LEICA 2135 microtome from its surface with thickness of 100 μm (named "front"), 400 μm ("middle") and 200 μm ("back") (Fig. 2). The sliced samples were subjected to thermal analysis using Differential Scanning Calorimeter (DSC) to examine the distribution of polycarbonate oligomers at 20°C/min scanning rate with temperature 50-180°C and sample weight was 3.5-5.5 mg.

Table 1 Blending and injection conditions of PC/PC oligomer.

No.	Materials	Code	Cylinder Temp. (°C)	Mold Temp. (°C)	Injection Speed (mm/sec)
A	PC + AL5%	350-80-60	350	80	60
B	PC + AL5%	350-80-120	350	80	120
C	PC + AL5%	350-80-200	350	80	200
D	PC + AL20%	350-80-60	350	80	60
E	PC + AL20%	350-80-120	350	80	120
F	PC + AL20%	350-80-200	350	80	200
G	PC + AL20%	350-100-120	350	100	120
H	PC + AL20%	370-80-120	370	80	120

Note: 1. PC: Polycarbonate.

2. AL5% and AL20%: Polycarbonate oligomer amount 5 wt% and 20 wt%, respectively.

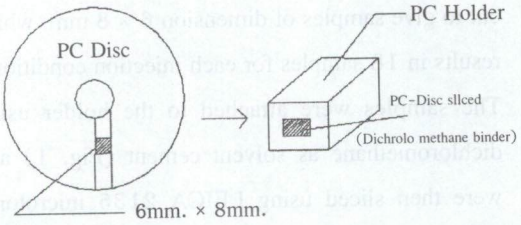

Fig. 1 *Attachment of a sample to the holder*

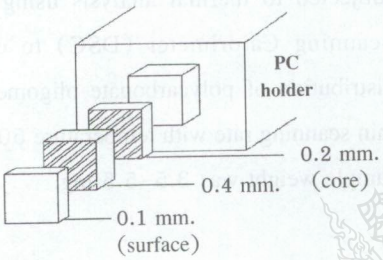

Fig. 2 *Sample slice using Microtome.*

3. RESULTS AND DISCUSSION

T_g measurement of polycarbonate and polycarbonate oligomers in the samples are shown in Fig. 3 and Fig. 4.

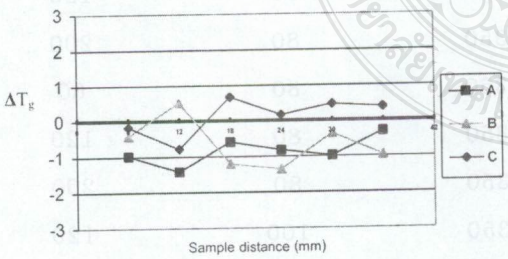

Fig. 3 *Glass temperature difference (ΔT_g) of samples **A, B, C** (oligomer 5 wt%).*

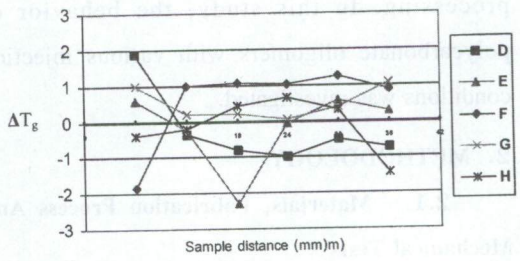

Fig. 4 *Glass temperature difference (ΔT_g) of samples **D, E, F, G** and **H** (oligomer 20 wt%).*

For 5% oligomer (samples **A, B** and **C**, Fig. 3), in sample **A** (AL5%, 350-80-60), T_g on the surface are lower than that in the core in every point of measurement and deviation of data are low, verified that the appearance of polycarbonate oligomer on the surface are more than in the core. Compare the phenomena with samples **B** and **C**, it can be seen that the ΔT_g of the two samples inclined to plus value, verified that the appearance of the oligomer on the surface are lower than those appeared in the core. The results of 20% oligomer (Samples **D, E** and **F**, Fig. 4), sample **D** (AL20%, 350-80-60) showed the similar results in the case of the 5% oligomer when compared with sample **E** and **F**. From the results, it can be concluded that in the injection condition using low injection speed (60 mm/sec) resulted in the diffusion of polycarbonate oligomer to the surface. The results are concerted with the theory of behavior of plastics in the mold[3]; increasing the injection speed, the molecular orientation of plastics in the mold are increased and resulted in lower diffusion of the oligomer to the surface.

In the case of same injection conditions but different mold and cylinder temperature from Fig. 4, it can be concluded that increasing the mold

temperature results in difference of T_g more that increasing the cylinder temperature. The explanation of phenomena in the case of increasing mold temperature is that the cooling rate of the mold is slow giving more time for plastic orientation in the mold. Then, the increasing of mold temperature has more influence to the orientation of plastics more than the cylinder temperature variation. Compared the oligomer constitutions in the same injection conditions (Fig. 3 and Fig. 4), it can be seen that the low content of oligomer (AL5%) showed the better results of oligomer distribution to surface.

4. CONCLUSIONS

Effects of polymer constitutions and injection conditions for the polymer blends of polycarbonate and polycarbonate oligomer systems were studied. It was found that oligomer content as well as injection speed and mold temperature influenced to the distribution of oligomer on the surface of the products, while the cylinder temperature has no significant influence to the orientation of the oligomer. The results may be applied to other polymer blends of high molecular weight and oligomer systems.

5. REFERENCES

[1] Douglas A. Skoog and James J. Leary (1992) Principles of Instrumental Analysis, Philadelphia: Saunders College Publishing.

[2] Franksettle (1997), Handbook of Instrumental Technique for Analytical Chemistry, New Jersey: Prentice Hall Inc.

[3] J. A. Brydson (1975), Plastic Materials, New York: Butterwoekth Publishers. Inc.

[4] John Scheirs (2000), Compositional and Failure Analysis of Polymers, England: John Wiley and Sons Ltd.

[5] R. V. MilbyI (1973), Plastics Technology, New York: McGraw-Hill, Inc.

[6] Pravin L. Shah (1990), Handbook of Plastic Materials and Technology, New York: John Wiley & Sons Inc.

[7] Terry L. Richardson (1989), Industrial Plastics: Theory and Application, New York: Delmar Publishers. Inc.

ประวัติผู้เขียนบทความ

Name: Dr. Sommai Pivsa-Art

Position: Lecturer, Associate Dean of Faculty of Engineering

Educational Background:

1998 Ph.D. in Engineering (Chemical Engineering), Osaka University, Japan

Address: Faculty of Engineering, Rajamangala Institute of Technology, Klong 6, Thanya-buri, Pathumthani, 12110, Thailand

Tel. (66)2-5493485

Fax. (66)2-5493406

E-mail: psommai@rit.ac.th