Title	ポリカーボネートを用いた新規相溶性ポリマーブレンドの創発と温度勾配による高機能化
Author(s)	長谷川, 弘侑
Citation	
Issue Date	2026-03
Type	Thesis or Dissertation
Text version	ETD
URL	https://hdl.handle.net/10119/20609
Rights	
Description	Supervisor: 山口 政之, 先端科学技術研究科, 博士

Development of novel miscible polymer blends based on polycarbonate and their functional enhancement under temperature gradients

Hiroyuki Hasegawa

This study aimed to develop miscible polymer blends based on polycarbonate (PC) that achieve both optical transparency and mechanical robustness, while also establishing new methods for functional control. To this end, three integrated approaches were investigated: (1) miscibility and property control in PC/copolyester (CPE) blends, (2) formation of concentration-gradient structures in PC/polymethyl methacrylate (PMMA) blends driven by temperature gradients, and (3) the elucidation of the governing factors that suppress the formation of concentration-gradient structures using the CPE/PC system.

Chapter 2　The thermal, mechanical, and viscoelastic properties of transparent PC/CPE blend films were analyzed in detail. The PC/CPE system exhibited miscibility across the entire composition range, yielding transparent films without light scattering due to phase separation. The glass transition temperature (T_g) followed the Fox equation. Increasing CPE content reduced Young's modulus and yield stress while increasing elongation at break, a trend attributed to the decrease in the entanglement molecular weight (M_e) caused by CPE. The reduction in M_e facilitated stress dissipation, resulting in enhanced toughness. These findings demonstrate that simple melt blending without chemical reaction produces transparent, highly ductile glassy polymer blends. Moreover, because T_g, melt viscosity, and modulus can be tuned by blend ratio, the system offers high applicability to various molding processes such as injection and stretching.

Chapter 3　Miscible PC/PMMA blends were investigated to characterize molecular-weight-dependent segregation under temperature gradients. After confirming miscibility via a single glass transition, ATR-IR analysis showed that the low-molecular-weight component (PMMA-L or PC-L) consistently migrated toward the high-temperature side. This behavior was driven by the higher free-volume requirements of shorter chains. The resulting stable concentration-gradient structure was determined by the temperature difference, independent of sample thickness. Furthermore, surface enrichment of PMMA-L enhanced Martens hardness, offering a novel surface-modification technique. These findings demonstrate that temperature gradients can induce stable gradient structures without phase separation, providing a new strategy for controlling surface and optical properties in transparent miscible blends.

Chapter 4　The segregation of miscible CPE/PC blends under temperature gradients was evaluated to identify factors inhibiting concentration-gradient formation. While viscoelastic and DSC analyses confirmed miscibility, no distinct gradient structure formed in the melt. Given the high blend fluidity, kinetic limitations were ruled out as the primary cause. Instead, the lack of segregation arises from strong thermodynamic interactions between components. High-temperature ATR-IR confirmed specific interactions between CPE and PC carbonyl groups. These attractive forces thermodynamically stabilize the uniform state, effectively offsetting the flux driven by free-volume differences and suppressing gradient formation. This study clarifies that such specific molecular interactions act as a critical governing factor that can override thermal driving forces in structural control processes.

Chapter 5　This chapter provides a general summary.

Key words　Polycarbonate, Polymer blend, Miscibility, Segregation, Viscoelasticity