

Understanding the molecular interaction and crystallisation behaviors in poly (3-hydroxybutyrate)/cellulose acetate butyrate blends

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Introduction

The wastes of non-degradable plastic products have caused a serious environmental problem. Biodegradable polymers are the most suitable alternative substances for replacement of these. Poly (3-hydroxybutyrate) (PHB), an environmentally-friendly polymer with great biodegradable properties, is consumed, and reduced by bacteria as an energy source. The utilisation of PHB has been limited, mainly because of its excessive crystallinity. For improving the special features of PHB, Cellulose acetate butyrate (CAB), another biodegradable polymer, has been selected to blend with PHB for its molecular interaction and easy production from cellulose, as observed in previous studies. Comprehensive understanding of the interaction and crystallisation is very important in the polymer process for controlling the physical properties and morphologies of the final semi-crystalline polymer. In the present study, near infrared (NIR), infrared (IR) spectroscopy and wide angle x-ray diffraction (WAXD) were employed to investigate the molecular interaction and crystallisation behaviours of PHB and CAB blends.

Materials and methods

Bacterial PHB and CAB were purchased from the Aldrich Chemical Co., Ltd. and were used as received. The specimens of PHB/CAB blends in various ratios were obtained in hot chloroform solution. The IR spectra from 4000 to 800 cm⁻¹ were obtained in standard transmittance mode on a Magna 870 spectrometer (Thermo Nicolet) by casting the blends on CaF₂. For NIR measurements, samples were cast onto a glass plate to control thickness at about 1 mm, and scanned in transmittance mode in the region of 10000–4000 cm⁻¹ (Perkin/Elmer, USA). The

X-ray data were recorded from thin films cast on a Cu plate. The X-ray source was generated at 50 kV and 50 mA by Cu- K_{α} radiation (wavelength: 0.15418 nm).

Results and discussion

From C=O and O-H stretching regions in the IR and NIR spectra of pure PHB, pure CAB and blends, that we obtained at room temperature, three types of C=O could be classified (Figure 1).

The first type is free C=O stretching bands located at 1759 cm^{-1} and 5290 cm^{-1} for CAB. The second type is C=O in crystal structure of PHB content that were assigned to 1724 cm^{-1} 5128 cm^{-1} . The last type includes hydrogen bonded C=O stretching bands from the intermolecular interaction between CAB and PHB. It occurs in the region of $1747\text{--}1742\text{ cm}^{-1}$ and $5167\text{--}5160\text{ cm}^{-1}$ in IR and NIR spectra, respectively. Moreover, the interaction stretching bands shift to higher wavenumbers, which indicates that the intermolecular interaction becomes stronger with the increasing PHB content. The WAXD patterns of blends present a sharp 020 diffraction peak around 13.4° , while the 110 peak around 16.7° is weak, even at high concentrations of PHB. Moreover, the intensities and shapes of the WAXD pattern become broad and weak, as a result of the increasing percentage of CAB. It seems that the introduction of CAB tends to decrease the crystallinity of PHB content.

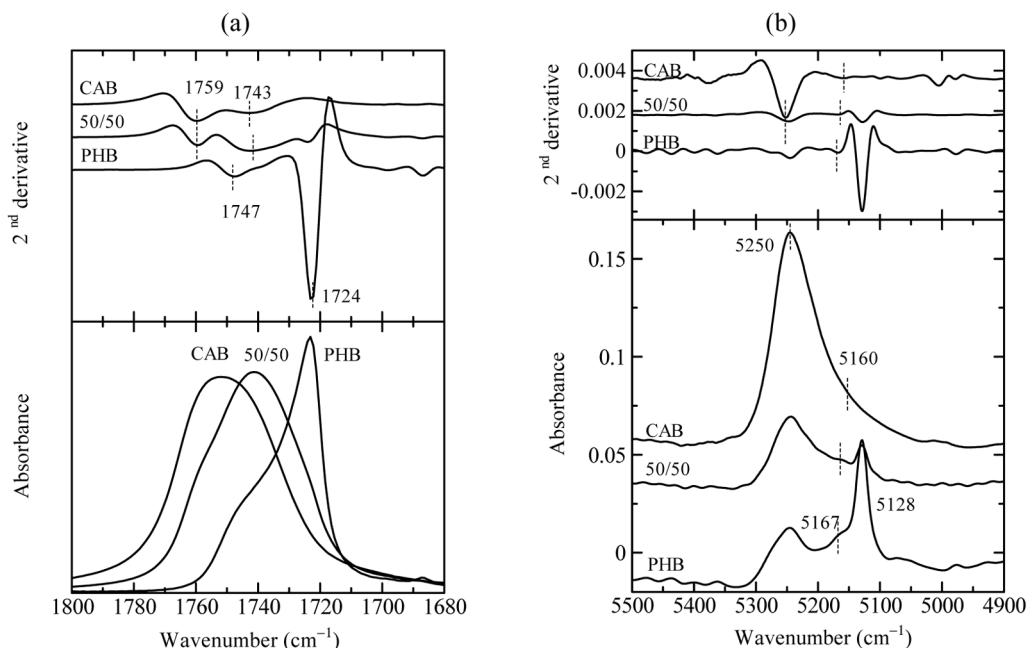


Figure 1. The absorbance and 2nd derivative (a) IR, (b) NIR spectra in C=O stretching region of PHB/CAB blends.

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