Tensile Properties of Pla And Phbv Blends: Anomalous Elongation and Aging

Thibaut Gérard, Tiffany Noto, Tatiana Budtova

TENSILE PROPERTIES OF PLA AND PHBV BLENDS: ANOMALOUS ELONGATION AND AGING

T. Gérard, T. Noto and T. Budtova

Mines ParisTech, Centre de Mise en Forme des Matériaux (CEMEF), UMR CNRS 7635, Sophia Antipolis, France
tatiana.budtova@mines-paristech.fr

INTRODUCTION

Polylactide (PLA) and polyhydroxyalkanoates (PHA) are polymers made from renewable resources. Despite their growing competitiveness with conventional petrol-based polymers, they still have some disadvantages such as poor (fragile) mechanical properties. Blending is a potentially prospective way of obtaining new materials with improved properties, which can overcome the drawbacks of the pure components.
In this work, PLA and poly(hydroxybutyrate-co-hydroxyvalerate) (PHBV) blends were prepared via melt mixing. Their morphology was observed by scanning electron microscopy and their tensile properties were studied.

EXPERIMENTAL

Materials

PHBV was purchased from Tianan Biological Materials Co. Polylactide (3051D, injection molding grade) used in the study was supplied by NatureWorks Co. Ltd., USA.

Preparation

PLA and PHBV blends were prepared by melt mixing in an internal batch mixer (Haake Rheomix 600). The PLA/PHBV compositions prepared were 0/100, 10/90, 20/80, 30/70, 40/60, 50/50, 60/40, 70/30, 80/20, 90/10 and 100/0 (w/w). Tensile specimens (ISO 527 – 1BA) were injected with a mini injection moulder (Haake Mini-Jet II).

Characterisation

Differential scanning calorimetry was used to study the miscibility and thermal properties of the PLA/PHBV blends. The blend morphologies were investigated using a scanning electron microscope (SEM). Tensile tests were performed for all blend compositions at a constant crosshead speed of 5 $mm.min^{-1}$ with an Erichsen tensile testing machine equipped with a load cell of 2 kN.

RESULTS AND DISCUSSION

The glass transition and melting temperature of PLA and PHBV were almost constant for all the range of compositions tested and coincided with transition temperatures of the pure components, showing the immiscibility of the PLA/PHBV binary blends.
Blends with a minor phase (either PLA or PHBV), below 30 wt%, showed a nodular structure. For example, Figure 1 presents a SEM micrograph of a fractured surface for a 70/30 PLA/PHBV blend. Droplets of PHBV are embedded in the PLA matrix.

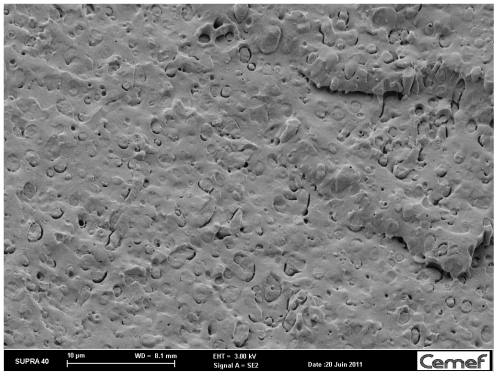

Fig. 1. SEM micrograph of a PLA/PHBV fractured sample with weight ratio 70/30.
The scale is 10µm.

Tensile tests were performed for all the blend compositions (from 0/100 to 100/0). Pure PLA and pure PHBV showed a small elongation at break (about 4%) and had relatively close Young's modulus (2.6 GPa for PLA and 2.3 GPa for PHBV). Figure 2a shows the evolution of the elongation at break as a function of PLA weight fraction in the blends. For the majority of the blends, the mechanical behaviour was similar to the one of the pure components. However, we observed a significant necking for compositions containing PHBV in minor phase (between 5 and 20 wt%). The 90/10 PLA/PHBV blend exhibited significant ductile plastic deformation: elongation at break reached more than 200%.

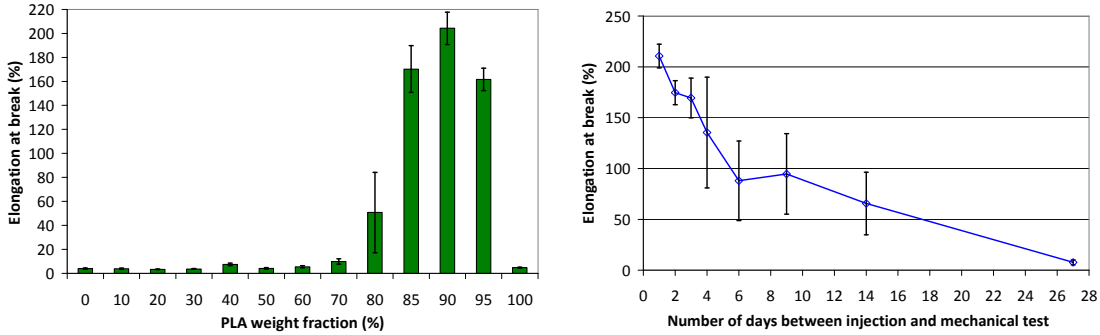

Fig. 2. a) Elongation at break as a function of PLA weight fraction in the PLA/PHBV blends and b) Evolution of elongation at break of a 90/10 blend versus time

We observed that the elongation at break of 90/10 PLA/PHBV blends strongly decreased in three weeks (Figure 2b). This aging and the influence of additives used to slow down the aging will be discussed.

Acknowledgement
The present work is performed in the frame of the Industrial Chair on Bioplastics, organised by CEMEF/MINES ParisTech and supported by Arkema, L'Oreal, Nestlé, PSA and Schneider Electric through the "Fondation des Industries Minérales, Minières et Métallurgiques Françaises".