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DEVELOPMENT OF BIODEGRADABLE POLY(HYDROXYBUTYRATE-CO-HYDROXYVALERATE) AND POLY(BUTYLENE SUCCINATE-CO-ADIPATE) BLENDS: TOUGHENING EFFECT

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Introduction

Materials with strong environmental impact are still used in disposable products such as food packaging materials. Alternative materials bio-sourced or biodegradable are highly desirable. Polyhydroxyalkanoates (PHAs), obtained from microbial fermentation, meet the two qualities by being bio-based and biodegradable but show a lack of properties showing a relatively high stiffness and brittleness while showing a relatively high glass transition temperature (0-5°C) compared to its counterpart low density polyethylene².

A conventional strategy to improve thermomechanical properties of the polymer consists in blending the brittle material with a ductile material. We report the results of blending PHBV with poly(butylene succinate-co-adipate) (PBSA) by melting state at different PHBV/PBSA content weight ratio. PBSA is a biodegradable aliphatic polyester, showing a low melting temperature, good thermal stability and low glass transition temperature (-45°C).

Materials & Methods

Commercial PHBV, under the trade name PHI 002 containing 3 mol% HV according to its technical data sheet and PBSA under the trade name PBE 001 were purchased from NaturePlast. The materials were dried at 70 °C for at least six hours, melt-blended in a mixing chamber of an internal mixer SCAMEX Rheoscam (France) at 190 °C for 9min at 90rpm and finally processed by thermal molding at 180 °C and 150 bars (SCAMEX 15T, France). The effect of PBSA content on the glass transition temperature (T_g) of PHBV was investigated by Dynamic Mechanical Analysis (DMA) using a TRITEC 2000 DMA (Triton Technology Ltd., UK) by applying a temperature scan from -60 °C to 190 °C. The thermal stability of the blends was investigated by Thermo-Gravimetric Analysis (TGA, Q500, TA Instruments) in Hi-Res Mode. An Environmental Scanning Electronic Microscope (ESEM, FEI Quanta 200) was used to characterize the phase morphology. The samples were first cryo-fractured using liquid nitrogen and then sputter-coated with a thin gold layer (Sputter coater Emitech K550).

Results & Discussions

Figure 1 shows the evolution of the torque measured in the mixing chamber during blending. A large decrease in torque is observed when the PBSA is increased beyond 50wt%. This evolution is consistent with the decrease in viscosity of the binary blends. The drop of viscosity at a particular threshold was tested and showed that beyond 50wt% PBSA, melting properties of the binary mixtures in the mixing chamber were driven by PBSA. At high quantities of PBSA, an increase in torque can be observed over time, which could be due to a cross-linking between PHBV and PBSA.

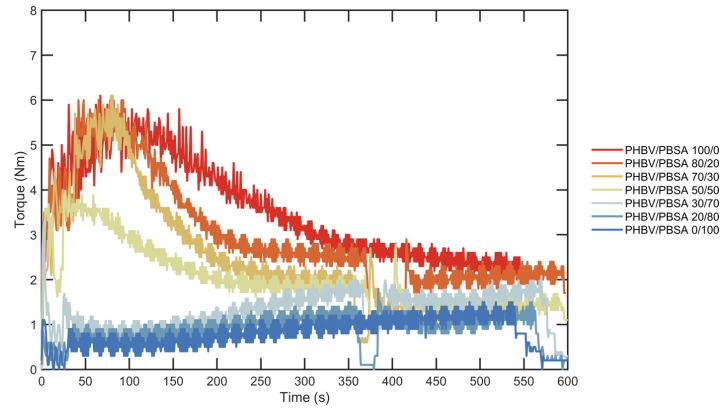


Figure 1: Measurement of torque over time during melt mixing of PHBV and PBSA

Figure 2 shows the obtained phase morphology for the binary blend PHBV/PBSA 70/30 w/w and present nodular structures. While, DMA results presented in Figure 3 show the broadening of the T_g peak which suggests the presence of three phases, pure PHBV, pure PBSA and mixed PHBV/PBSA and correlates with the assumption of crosslinking made previously. The mixture has two T_g values with a value associated to PHBV phase decreased to 18.3 °C from 21.6 °C. PBSA increased the chain mobility of PHBV in the miscible region and hence conferring a toughening effect. Finally a significant improvement of thermomechanical properties of PHBV/PBSA blends comparatively to neat PHBV is obtained.

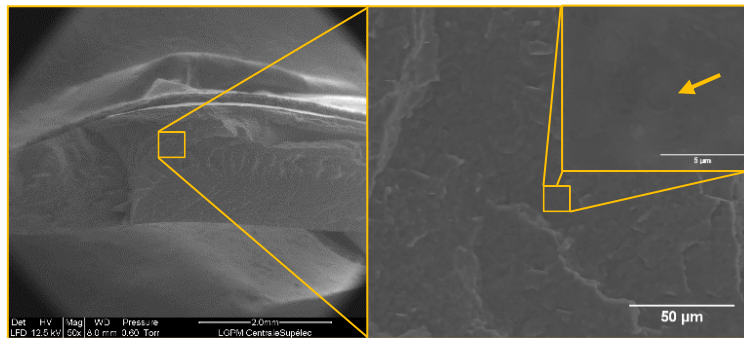


Figure 2: SEM images of cryo-fractured surfaces of PHBV/PBSA 70/30 w/w

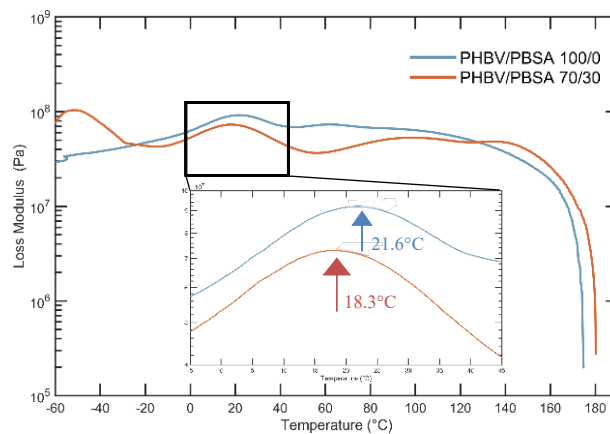


Figure 3: Loss Modulus of PHBV/PBSA blends with temperature (DMA measurements)

References

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2. Corre, Y.-M., Bruzaud, S., Audic, J.-L. & Grohens, Y. *Polym. Test.* **2012**, *31*, 226–235.