行政院國家科學委員會補助專題研究計畫成果報告

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回收聚乙烯醇縮丁醛與韌化尼龍 6,6 之摻合研究

(The study on the blend of Polyvinyl butyral and toughened Nylon 6,6)

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計畫類別： 個別型計畫

計畫編號：NSC 89-2216-E-034-006

執行期間： 88 年 8 月 1 日至 89 年 7 月 31 日

計畫主持人：賴森茂

執行單位：文化大學化工系

中 華 民 國 89 年 10 月 17 日

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中文摘要

本研究於 Nylon 6，6 中加入回收聚乙烯醇縮丁醛 (Polyvinyl butyral，PVB) 彈性體，並以 SEBS-g-MA (馬來酸酐改質 SEBS)作為相容劑，針對機械性質變化作探討。 結果顯示在抗張強度等機械性質方面，PVB 與 SEBS 彈性體在 Nylon6, 6 合膠中相近。同時 PVB 與 Nylon6, 6 之相容性可藉由 SEBS-g-MA 做改善，並提高合膠之耐衝擊強度。

關鍵詞:尼龍 6, 6，聚乙烯醇縮丁醛，機械性質

Abstract

Mechanical properties of Nylon 6,6/PVB including impact strength at various temperatures and brittle-ductile transition were investigated. The function of PVB resembles that of a SEBS copolymer in a Nylon 6,6 blend system regarding tensile strength, elongation etc. A SEBS-g-MA copolymer was incorporated as a compatibilizer to improve the impact resistance between Nylon 6,6 and PVB.

Key words: Nylon 6,6 Polyvinyl butyral， mechanical properties

Introduction

There has been of great commercial interest in polymer blends containing recycled materials because the technology offers a potential and economic route to new products with combined attractive features of each material. [1,2]

Nylon 6,6 is one of widely used engineering plastics. However, many drawbacks remain to be improved, such as brittleness and high moisture absorption. One of approaches is to blend Nylon 6,6 with various types of rubbery polymer including styrene-ethylene-butylene-styrene block copolymer (SEBS) etc. A compatibilizer has usually been incorporated to further improve impact resistance. [3-5]

Few studies have been done on the recycled PVB (Polyvinyl butyral) blend.[6,7] PVB film has been widely used as the interlayer in automobile safety glasses due to its toughness, light stability, clarity, and insensitivity to moisture and good adhesion to glass. Cha et al. [7] reported that blends up to 35 wt. % PVB show higher mechanical properties than those of Nylon 6 blended with conventional impact modifier styrene-ethylene-butylene-styrene. The objective of this research is further to exam this possibility in achieving a super tough Nylon/SEBS-g-MA/PVB blend and explores a really practical route to recover the loss of PVB scrap film.

Experimental

Materials: The materials used in this study were Nylon 6,6(Dupont, Zytel 101L), SEBS-g-MA (Shell, Kraton 1901X) and SEBS(Shell Kraton G1652) and PVB,. Polyvinyl butyral is a copolymer of vinyl butyral-co-vinyl alcohol-co-vinyl acetate. Recycled PVB film, used as received, is collected from the trimmed scrap around the edge of glasses laminate during production.

Sample preparations: Mixing of Nylon 6,6 and PVB with a SEBS-g-MA as compatibilizer was carried out using a co-rotating twin-screw extruder of type Kobe KTX-30.

Mechanical tests: Tensile measurements were conducted using an Instron Machine model 4204. Notched Izod impact test was performed using Custom Scientific Instruments CS-137 at various temperatures ranging from -40℃ to room temperature.

Rheology: For rheological characterization, the melt viscosities of those blends were determined at 280℃ under various shear rate ranging from 10 to 10^3 1/sec using Gottfert Rheometer.

Results and Discussion

Mechanical properties:

Table 1 shows the results of flexural and Tensile measurements for three blends of Nylon 6,6 with PVB, SEBS, SEBS-g-MA respectively at a representative blend composition of Nylon 6,6/elastomer = 85/15. Mechanical properties of blend (Nylon 6,6/PVB) including Flexural strength, etc. are reported to 20% lower than those of unmodified Nylon 6,6 except a moderate improvement in the tensile strength and elongation. Similar observations were also found for Nylon 6,6 blended with SEBS, except a better performance for PVB in terms of tensile strength and elongation. Unlike Cha's finding [7], PVB offers better performance than SEBS in terms of impact resistance for their Nylon 6 blends system. When SEBS-g-MA, a commonly used compatibilizer and impact modifier for Nylon 6,6, is also chosen for the comparison, the mechanical properties for the resulting blend (Nylon 6,6/SEBS-g-MA) unexpectedly resembles to those of Nylon 6,6/PVB system. To further investigate the role of PVB in those blends, tensile and flexural properties with different amounts of PVB are shown in Fig. 1 and 2.

Though the incorporation of PVB seems to increase certain mechanical properties of Nylon 6,6 blends, the impact strength at various temperatures for Nylon 6,6/PVB are still 30% lower than for unmodified Nylon 6,6. Similar results are found for Nylon 6,6/SEBS as shown in Fig. 3. SEBS-g-MA was therefore incorporated to improve the interface interaction between PVB dispersed phase and Nylon 6,6 matrix. The impact strength for this compatibilized system is higher than for the unmodified system as shown in Fig. 4. With increasing the compatibilizer content, the impact strength was increased dramatically up to 20 times, ca. 800 J/m, esp. results at room temperature.

When similar tests were performed at a thickness of 1/4", most samples failed in a brittle behavior. Over the investigated temperatures, the Nylon 6,6/ PVB system without a compatibilizer still gave low impact strength. With increasing compatibilizer content, the impact strength increased slightly up to 4 times, reaching 150 to 200 J/m. As the brittle-ductile transition temperature (BDTT) is affected by the sample thickness, the results for Nylon 6,6 blend containing various amounts of elastomers (SEBS-g-MA) with two different types of specimen, 1/8" and 1/4" thick are shown in Fig. 6. For a fixed elastomer modified systems, the BDTT is higher for thicker sample. Furthermore, the brittle-ductile transition temperature increased dramatically with increasing PVB content (or decreasing SEBS-g-MA content) for a fixed elastomeric dispersed phase. It implies SEBS-g-MA for this Nylon 6,6 /PVB blend system performs not only a compatibilizer but also an impact modifier. Results on the observations on fracture surface will be published in a separable paper.

Rheology:

Effects of SEBS-g-MA on the apparent viscosity of Nylon 6,6/PVB blend system are shown in Fig. 7. With increasing SEBS-g-MA content, the melt viscosity increased slightly at various shear rates. It suggests the interfacial interaction has been improved resulting from the chemical reaction of maleic anhydride group of the compatibilizer with the amine group on the Nylon matrix. This in turn improves the mechanical properties of unmodified Nylon 6, 6/PVB blend.

Conclusions

The function of PVB resembles that of a SEBS copolymer in a Nylon 6,6 blend system regarding tensile strength, elongation etc. A SEBS-g-MA copolymer was incorporated as a compatibilizer to improve the compatibility between Nylon 6,6 and PVB. As the content of the compatibilizer increased, the impact resistance at all investigated temperatures increased. A brittle to ductile transition is sometimes observed depending sample geometry. Higher values of brittle-to-ductile transition temperature were seen as the PVB content increased.

Evaluations

Most of proposed works have been carried out through this study and will be published.

Acknowledgements

Grants from National Science Council of Taiwan, R.O.C. are gratefully acknowledged.

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Table 1: Mechanical properties of PA66, PA66/PVB, PA66/SEBS and PA66/SEBS-g-MA

	PA66	PA66/PVB 85:15	PA66/SEBS 85:15	PA66/SEBS-g-MA 85:15
Flexural modulus (MPa)	1980± 5	1452± 16	1612± 59	1333.0± 3.0
Flexural strength (MPa)	83.30± 0.52	57.95± 0.36	64.58± 0.92	57.80± 0.58
Tensile modulus (MPa)	2995± 57	2380± 4	2448± 63	2161± 176
Tensile strength (MPa)	37.12± 1.57	53.55± 0.3	43.93± 1.70	43.28± 0.22
Elongation (%)	34.45± 0.37	74.71± 10.02	49.13± 7.73	72.90± 5.98

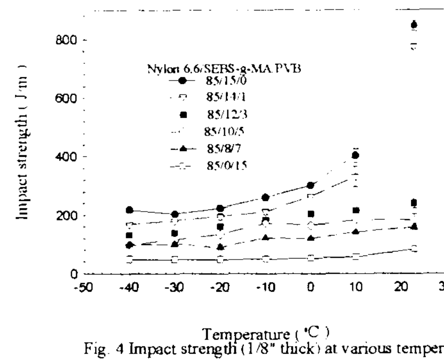

Fig. 4 Impact strength (1/8" thick) at various temperatures for SEBS-g-MA compatibilized Nylon 6,6/PVB.

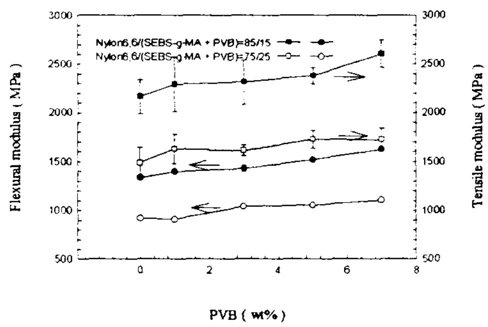

Fig. 1 Effect of PVB content on the flexural modulus and tensile modulus for both Nylon 6,6/(SEBS-g-MA+PVB) = 85/15and 75/25, respectively.

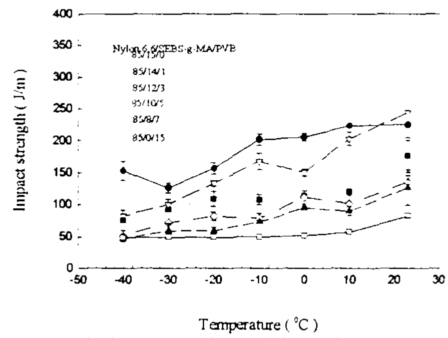

Fig. 5 Impact strength (1/4" thick) at various temperatures for SEBS-g-MA compatibilized Nylon 6,6/PVB.

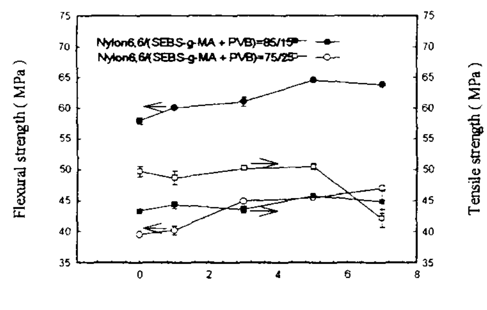

Fig. 2 Effect of PVB content on the flexural strength and tensile strength for both Nylon 6,6/(SEBS-g-MA+PVB) = 85/15and 75/25, respectively.

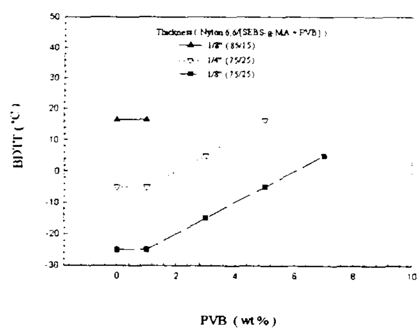

Fig. 6 Effect of PVB content and sample thickness on the the brittle-to-ductile temperature for both Nylon 6,6/ (SEBS+PVB)= 85/15and 75/25, respectively.

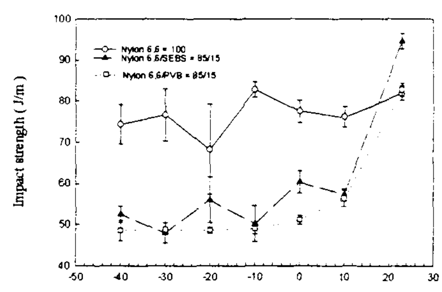

Fig. 3 Impact strength at various temperatures for Nylon 6,6, 15 wt% SEBS, and PVB modified Nylon6,6

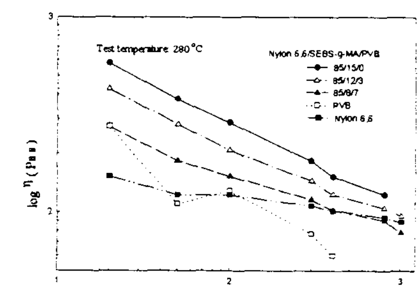

Fig. 7 Variations of viscosity with respect to shear rate for Nylon 6,6/SEBS-g-MA/PVB system.