

THERMAL PROPERTIES OF POLY(VINYL CHLORIDE)/POLYURETHANE BLENDS

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Abstract

Blends of poly(vinyl chloride) and a polyurethane elastomer were investigated by DSC and tensile testing. Up to 30 wt% single glass transition was found. It was concluded that the polyurethane forms partly a true blend and is partly dispersed in the continuous blend phase.

Keywords: blends, DSC, polyurethane, poly(vinyl chloride)

Introduction

The modification of polymer properties through blending allows to obtain inexpensive materials with improved characteristics. Poly(vinyl chloride) is a rigid and rather brittle polymer and it usually fails by a brittle type fracture. The incorporation of elastomeric material in poly(vinyl chloride) results in decreased yield stress and increased elongation at break. Miscible blends of poly(vinyl chloride) were obtained with poly(ϵ -caprolacton) [1] epoxydized natural kautchuk [2], poly(methyl methacrylate) [3]. With polyurethanes miscible and immiscible blends are known [4, 5].

Experimental

Materials

Commercial grade of poly(vinyl chloride) (PVC)–Polyvinyl "S" from "Włocławskie Zakłady Azotowe" was used. The polyurethane of hardness of 84°ShA (TPU-84) was synthesised from poly(butylene, ethylene)adipate (Poles 55/20, Zakłady Chemiczne "Zachem"), 4,4'-diisocyanate diphenylmethane (Suprasec, ICI) and 1,4-butanediol (B.A.S.F.).

Compounding

The poly(vinyl chloride) and the thermoplastic polyurethane were melt mixed on a single screw injection moulding machine. 1% of dibutylphthalate

and 1% of a tin containing stabilizer was added prior to processing. Specimens of dimensions 105 mm × 60 mm × 2.5 mm were formed.

Differential scanning calorimetry (DSC)

Thermal properties were estimated on Perkin–Elmer DSC 7 with the Data Station 3700. The calorimeter was calibrated with indium and water. Samples of ca 8 mg and a heating rate of 20 deg·min⁻¹ were used.

The samples were subjected to two consecutive temperature scans from -50 to 120°C. The glass temperatures were estimated from the second scan.

Tensile testing

Stress–strain measurements were performed on "Fritz Eckart" (Germany) tensile tester, equipped with a temperature chamber.

Results and discussion

In DSC curves single phase transition were observed for polyurethane concentrations in the blends up to 30 wt%. For 35 wt% and 40 wt% of TPU-84 additional low temperature transitions of amorphous soft segment polyurethane phase at -17°C were detected, which indicated immiscibility. The glass transition temperatures obtained from the DSC scans are presented in Table 1.

Table 1 Characteristics of glass temperature transitions of poly(vinyl chloride)/polyurethane blends

Wt% of TPU-84	Onset of T_g / °C	T_g / °C	ΔC_p at the glass transition/ $J \cdot g^{-1} \cdot deg^{-1}$
0	83	85.2	0.142
5	79.3	83.3	0.201
10	78.2	82.4	0.169
15	78.1	81.9	0.217
20	73.6	81.4	0.072
25	75.1	77.5	0.087
30	65.5	70.3	0.131
35	65.9	76.3	0.142
40	69.1	78.8	0.87

The obtained composition dependency of the glass temperature was not linear. The lowest value (70.0°C) was obtained for 30 wt% of TPU-84, the next

T_g -values increased, due to partial immiscibility, also indicated by low temperature T_g .

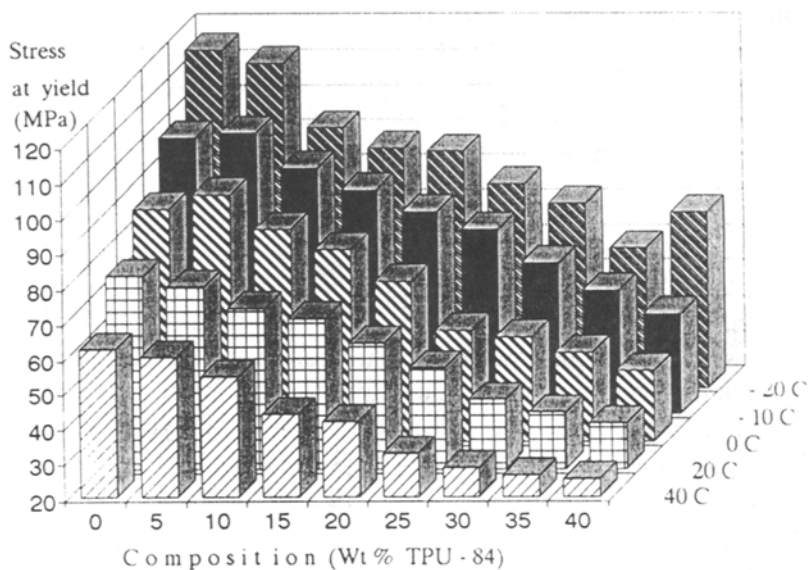


Fig. 1 Composition and temperature dependency of tensile yield stress of poly(vinyl chloride)/polyurethane blends

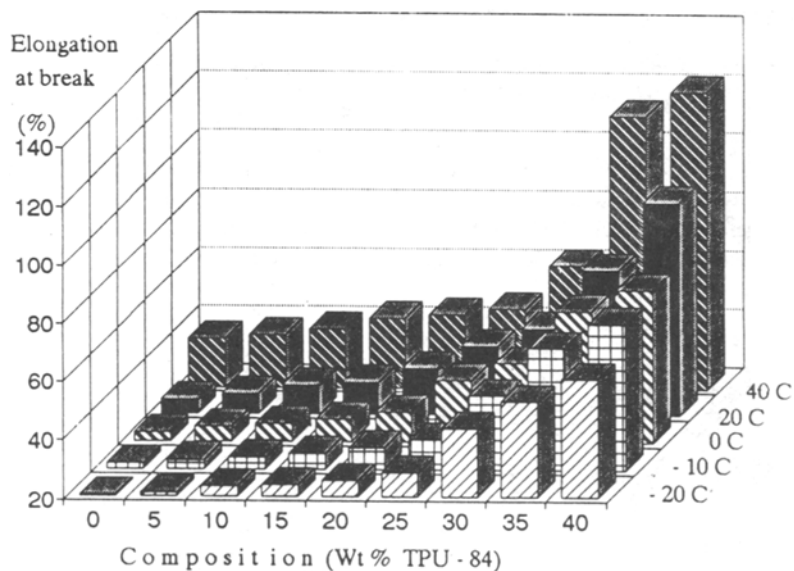


Fig. 2 Composition and temperature dependency of elongation at break of poly(vinyl chloride)/polyurethane blends

The tensile properties of the blends studies are plotted as functions of composition and temperature in Figs 1 and 2. The yield stress was defined as the first point of maximum stress on a stress-strain curve.

The yield stress decrease and elongation at break increase regularly with composition and with temperature, except for much higher values of elongation at 40°C obtained for samples containing 35 and 40 wt% of polyurethane, for which continuous polyurethane phase could be assumed.

Conclusions

The gradual change in T_g and in tensile properties with increasing fraction of polyurethane (up to 30%) is indication of phase mixing. Even if single glass temperatures were obtained, the decrease of their values was less than expected from the changes in composition. Therefore for the investigated blends some degree of microheterogeneity may be present in form of polyurethane dispersion plasticizing the rigid structure of poly(vinyl chloride).

References

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Zusammenfassung — Mittels DSC und Zugversuchen wurden Gemische aus Polyvinylchlorid und einem Polyurethanelastomer untersucht. Bis zu 30 Gew% wurde ein einzelner Glasumwandlungspunkt gefunden. Man schloß, daß Polyurethan teilweise ein echtes Gemisch bildet und teilweise hingegen in der kontinuierlichen Mischphase dispergiert ist.