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ORIGINAL PAPER

TPU/PCL/nanomagnetite ternary shape memory composites: studies on their thermal, dynamic-mechanical, rheological and electrical properties

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Abstract Shape memory polymer composites based on a blend of thermoplastic polyurethane (TPU) segmented block copolymer and poly(ε-caprolactone) (PCL) with weight ratio of 70/30 and various nanomagnetite contents (0–5 wt%) were prepared by melt blending of TPU and PCL, together with a masterbatch of TPU/nanomagnetite. The samples were compounded for 10 min at 200 °C using an internal mixer. Synthesized nanomagnetite powder was introduced to the masterbatch via a solution mixing method using a high-intensity ultrasonic horn. Subsequently, thermal, mechanical, rheological and electrical properties of the TPU/PCL/nanomagnetite shape memory composites were investigated through various tests. The degree of crystallization of the PCL component in the composite structure was inspected by differential scanning calorimetry (DSC) and X-ray diffraction measurements. The results revealed that the percentage of crystallinity and the melting temperature of the PCL component changed in the presence of magnetite nanoparticles, which was related to the nanoparticles acting as nucleants. Observing a single glass transition temperature (T_g) in DSC thermograms of the samples was indicative of good compatibility of the TPU and PCL components in the composite structure. This was also confirmed by dynamic-mechanical analysis in which the loss modulus curves showed a single glass transition temperature. Moreover, the loss modulus peak at glass transition was lowered and broadened by addition of nanomagnetite, by which it was assumed that introducing nanoparticles into the system changed the mechanism of glass transition due to particle–matrix interactions. The dynamic rheological and electrical resistivity experiments verified the existence of a low percolation threshold at about 2 wt% nanomagnetite. The state of nanomagnetite dispersion in the masterbatch and the microstructure of the ternary composites were characterized by scanning electron microscopy. Finally, adding nanomagnetite led to weakening of shape recovery of the polymer blend, with shape recovery dropping to 70 % at 5 % of nanomagnetite.

Keywords Shape memory polymers · Polyurethane · Poly(ε-caprolactone) · Nanomagnetite · Ternary composites

Abbreviations

TPU	Thermoplastic polyurethane
PCL	Poly(ε-caprolactone)
DSC	Dynamic scanning calorimetry
XRD	X-ray diffraction
DMA	Dynamic mechanical analysis
SEM	Scanning electron microscopy
SMP	Shape memory polymer
THF	Tetrahydrofuran
T_g	Glass transition temperature
T_m	Melting point
T_{trans}	Transition temperature
M_n	Number average molecular weight
ΔH_f	Heat of fusion
ΔH_{100}	Heat of fusion of 100 % crystalline material
E'	Storage modulus
E''	Loss modulus
WAXS	Wide angle X-ray scattering
G'	Storage shear modulus

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