Deformation behavior of polymer-clay nanocomposites

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Introduction

Nanocomposites based on polymers and organophilic clay minerals can exhibit improvement in various mechanical, thermal and optical properties. The objective of this study is to relate the microscopic deformation processes to the macroscopic mechanical behavior of these materials.

Material and methods

The nanocomposites based on HDPE matrix and Cloisite (5% wt) were produces via melt extrusion using HDPE grafted with maleic anhydride as compatibilaser. The samples for investigation were prepared via compression molding.
Morphological changes in the materials corresponding to the different points of the tensile curve have been studied on nano and micron length scales. To follow the deformation events real-time WAXS and SAXS and ESEM experiments during tensile tests have been carried out.

Results

The inelastic deformation of HDPE commences in the amorphous regions and is subsequently transferred also to a deformation of the crystalline part, involving different processes like crystallographic slip, mechanical twinning and martensitic transformations. Application of stress changes the crystal lattice of the PE from orthorhombic to monoclinic which is indicated by an extra reflection in WAXS pattern. From the fig. 1 it can be seen that in both pure and nanocomposite materials the martensitic transformations take place at about yield point. In the strain softening region the monoclinic crystals orient along the tensile direction. This orientation completes at the end of strain softening, as shown in Fig. 2.

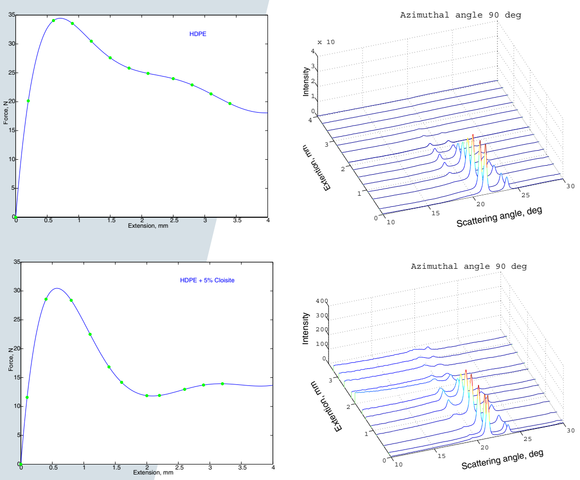


Figure 1 *The dots in force-extension curves correspond to the extensions in WAXS plots.*

HDPE | HDPE + 5% Cloisite

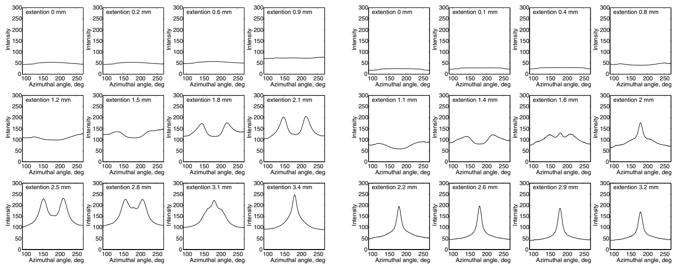
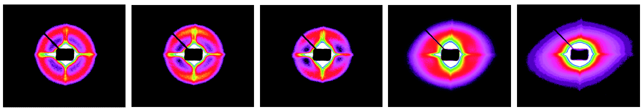
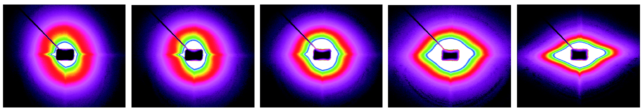


Figure 2 *Azimuthal WAXS patterns along the reflection of the monoclinic phase (at 2 Θ = 19.1 deg.)*



0 mm | 0.6 mm | 1.1 mm | 1.6 mm | 2.3 mm



0 mm | 0.6 mm | 1.1 mm | 1.6 mm | 2.6 mm

Figure 3 *SAXS and the corresponding extensions*

The SAXS patterns show an increase in interlamellar distance. The increase of intensity round the center is related to micro-void formation. As can be seen from the Fig. 3 the process is faster for the filled material, which could be a result of less tie molecules present.

HDPE | HDPE + 5% Cloisite

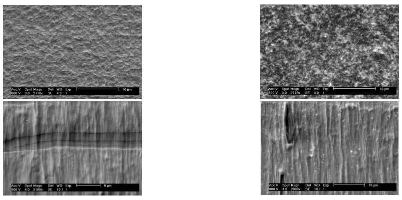


Figure 4 *ESEM micrographs of non-deformed and highly stretched samples showing the fibrous structure and the existence of the macro-voids in the filled samples.*

Conclusions

- ☐ The process of interlamellar separation is quicker in the HDPE-Cloisite nanocomposies
- ☐ The initiation of martensitic transitions is not affected by the by the presence on the nano-clay particles

References:

[1] Lin, L., Argon, A. S.: *Structure and Plastic Deformation of Polyethylene* Journal of Materials Science, 1994

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