Polymer-metal interfaces : an FTIR study

Polymer-metal interfaces : An FTIR study

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Introduction

Knowledge of the conformation of a polymer species in the interphase region is an important aspect to understand the mechanism of adhesion in composite engineering material and its ultimate deformation behaviour. Conformational differences of the polymer chains in the interphase region of a laminate and in bulk (free standing film) have been investigated to get in insight into the adhesion mechanism.

Materials and Method

PET-IF steel laminates were studied, which were prepared by spin casting of a PET solution on the uniformly deforming steel substrate. The steel was polished and cut into tensile bars. Free-standing PET films were made by casting on teflon sheet. Infra-red spectroscopy was performed *in-situ* during annealing in a Linkam hot stage, and during uniaxial loading in Micro tensile stage at different strains.

Results

Changes in conformation on annealing.

When comparing spectra of free standing film and laminate, fig 1, we observe significant differences in the peak positions and shapes.

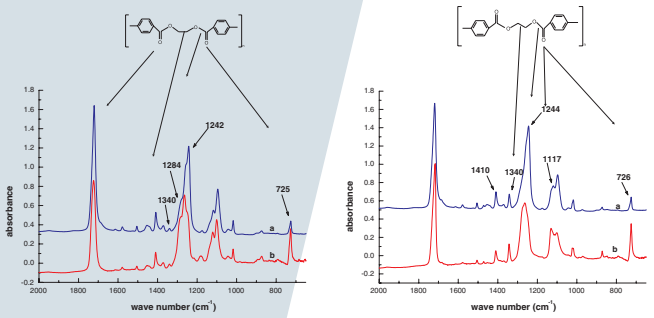

Figure 1 *Spectra of laminate (a) and free standing film (b) when amorphous (left) and semi-crystalline (right) after annealing.*

In laminate we observe:

- decrease in 1284 cm^{-1}and 1117 cm^{-1}, with alternate increase in 1242 cm^{-1} intensity, assigned to ring-ester of PET.
- reduced intensity at 1260 cm^{-1} and 1089 cm^{-1}, of glycol bands.
- remarkable reduction in 725 cm^{-1} assigned to C=O and C-H out of plane deformation .
- shift of 1725 cm^{-1} to 1721 cm^{-1} position, stretching vibration of C=O functional group.
- low ratio of 1340 cm^{-1} to 1410 cm^{-1} (measure of relative crystallinity [1]), in the semi-crystalline laminate.

From this we learn that:

- polymer chain conformations in free film and laminate differ, as evident from the glycol and ester bands.
- vibrations of C=O bond of the ring-ester are restricted.
- mobility of the polymer is restricted to the constraints set by the interface, as indicated by the reduced crystalline ordering on annealing in laminate.

Changes in conformation on uniaxial loading.

During loading of amorphous and semi-crystallised free films and laminates, significant changes are observed as shown in fig 2 and 3.

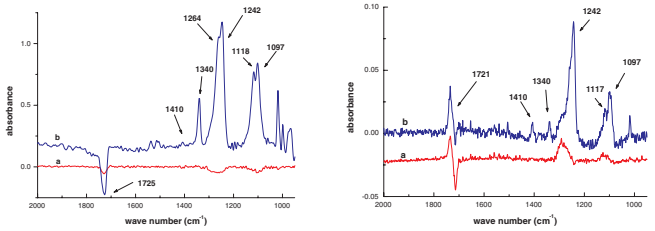

Figure 2 *Dichroic difference spectra of amorphous free film (left) and laminate (right) before loading (a) and at 25% macroscopic strain (b). In free film spectrum is taken from the neck.*

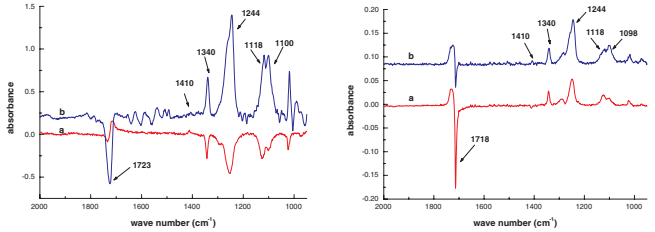

Figure 3 *Analogous to fig 2, but for semi crystalline film.*

In laminates we observe:

- spectra show dichroism before loading.
- negative dichroism in 1721 cm^{-1} band assigned to C=O stretching vibration, is significantly reduced.
- orientation insensitive band at 1410 cm^{-1} assigned to aromatic ring deformation, shows positive dichroism.

From this we suppose that:

- C=O orientation is restricted, indicating that probably it is involved in bonding to the metal.
- aromatic ring gets distorted on laminate loading, indicating restricted mobility of polymer chain.

Conclusions

- Conformations of polymer chains in free film and laminate are different due to the constraints set by the interface.
- C=O vibrations of PET on laminate are restricted when annealing and loading, indicating that it could be involved in bonding with the metal, thus resulting in restricted polymer mobility and distorted conformations.

References:

[1] Cole, K. C. Ajji, A, Pellerin. E.: *Macromolecules, 32, 2002*

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