Extended abstract

Energy saving in buildings is a topic widely studied for decades [1] and many regulations have been instituted worldwide (as an example RT 2005, RT 2012 for France). In addition to the conventional insulation materials (mineral, vegetal or animal wool), a huge amount of solutions, including renewable materials, have been developed (recycled cotton, aerogel, recycled polyester [2]). In this field of activities, our study will concern the analysis of the skin-core low melt fibre used for a thermal insulation nonwoven developed by PEG S.A.S. Thermal (Differential Scanning Calorimetry DSC, Modulated Temperature DSC, Nanoscale thermal analysis), optical (Scanning Electron Microscopy SEM), spectroscopic (Fourier Transform InfraRed spectroscopy FTIR) and mechanical (Atomic Force Microscopy AFM) investigations have been performed and the main results regarding sheath structure modification will be presented here: a molecular reorganization of the sheath occurs during spinning process.

The recycled-base PET core is coated by a co-Polyester (CAS number 27027-87-8), and both are High Speed spinned by the Irish company Wellman. The cross-section shape (Fig. 1) is obtained by microtome cut.
Fibres section shapes are irregular and the core isn’t perfectly centred in the sheath. As demonstrated by Kikutani et al. [3], this is due to a modification of viscosity between both materials occurring during the spinning process. The Modulated Temperature DSC signal obtained between 30 °C and 150 °C shows two endothermic transitions at 60 °C and at 120 °C (Fig. 2): the first one at 60 °C is attributed to the PET – core glass transition. The second observed at 120 °C has the shape of what could be expected for a glass transition, nevertheless as shown from microscopy this temperature corresponds to the melting of sheath part (Fig. 3).

To confirm the nature of this second endothermic transition we have extracted the sheath part. Two methods of extraction have been performed: first by extracting manually the sheath part at 130 °C, and the second by analysing the sheath raw material. In both cases, a single glass transition is visible around 60 °C which confirms
the co-polyester sheath nature. The endothermic transition around 120 °C shown in figure 2 isn’t apparent. As a consequence we assume that this signal is related to the spinning process.

Moreover, most of the peaks from the FTIR spectra obtained from sheath pellets (Fig. 4) correspond to a standard PET [4] (Tab. 1). Due to the low quantity of sheath extracted from the first method, no more FTIR experiments have been done.

<table>
<thead>
<tr>
<th>Wavelength (cm⁻¹)</th>
<th>Peak identification</th>
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<tbody>
<tr>
<td>1224</td>
<td>Ester group stretching</td>
</tr>
<tr>
<td>1713</td>
<td>C=O, ester bond</td>
</tr>
<tr>
<td>2957</td>
<td>=C-H, aromatic</td>
</tr>
</tbody>
</table>

Table 1. Peak identification. The sheath part is similar to polyester.

By using thermo-mechanical analysis (Nano-TA) combined with AFM, we can analyze directly the sheath part of the fiber [5]. Figure 5 shows the deflection in function of the sample temperature (heating rate: 10 °C/min). Two thermal transitions are visible: first around 130 °C which corresponds to the glass transition, and a second linked to the melting of the sheath from 200 °C. Furthermore, no signal change appears at 60 °C to confirm a structure modification caused by the process.

Figure 4. FTIR spectra. Sheath.

Figure 5. Nano thermal response. Sheath.
Cho et al. [6] have also observed huge glass transition temperature shifts from 60 °C for the raw material to 120 °C after fiber processing. From our investigations we have also clearly demonstrated the existence of such a molecular reorganization of the sheath during the spinning process.

The next step of this work is the characterization of a drawing filament from the sheath raw material: how does the spinning process impact the sheath/core structure? Why does the glass transition around 120 °C look optically like a fusion phenomenon?

References

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3. Kikutani, Takeshi; Radhakrishnan, J.; Arikawa, Sadaaki; Takaku, Akira; Okui, Norimasa; Jin, Xia; Niwa, Fumio; Kudo, Yosuke: Journal of applied polymer science (1996), 62(11), 1913-1924.
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