Dynamic Viscoelastic Data of Polyethylene

1. Sample
   Low Density Polyethylene : LDPE (Brand Name : Mirason 68)
   High Density Polyethylene : HDPE (Brand Name : Hi Zex 5000F)

2. Chemical Structure
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   \text{CH}_2 - \text{CH}_2 \]

3. Thermal History
   LDPE  Press film : after pressing at 150℃ allowed to cool to room temperature.
   HDPE  Press film : after pressing at 180℃ allowed to cool to room temperature.

4. Instruments
   SDM5500 Rheol. Station
   DMS100 Dynamic Mechanical Spectrometer

5. Conditions
   Deformation mode : Bending mode
   Sample Size :
   LDPE  20.00(ℓ) x 12.05(w) x 1.70(t)mm
   HDPE  20.00(ℓ) x 6.45(w) x 2.22(t)mm
   Temperature Range :
   LDPE  -150℃ ~ 90℃
   HDPE  -150℃ ~ 130℃
   Heating Rate : 2K/min
   Atmosphere : N₂
   Frequency : 0.5,1,2,5,10Hz

6. Transition temperature and activation energy based on tanδ

<table>
<thead>
<tr>
<th></th>
<th>LDPE</th>
<th></th>
<th>HDPE</th>
<th></th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Delta E (kJ/mol)</td>
<td>Transition Temp. (℃)</td>
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<td>Transition Temp. (℃)</td>
<td></td>
</tr>
<tr>
<td>α Transition</td>
<td>145</td>
<td>54 (1Hz)</td>
<td>119 (1Hz)</td>
<td>-</td>
<td>Crystal Relaxation</td>
</tr>
<tr>
<td>α’ Transition</td>
<td>-</td>
<td>-</td>
<td>79 (1Hz)</td>
<td>-</td>
<td>Grain Boundary relaxation</td>
</tr>
<tr>
<td>β Transition</td>
<td>-19 (1Hz)</td>
<td>-</td>
<td>-32 (1Hz)</td>
<td>-</td>
<td>Glass Transition</td>
</tr>
<tr>
<td>γ Transition</td>
<td>-124 (1Hz)</td>
<td>69</td>
<td>-121 (1Hz)</td>
<td>129</td>
<td>Local mode relaxation</td>
</tr>
</tbody>
</table>

7. Thermal Analysis Data
   LDPE  Tm : 106.2℃, ΔHm : 139.6 J/g, DSC 10K/min
   HDPE  Tm : 132.1℃, ΔHm : 219.4 J/g, DSC 10K/min
Comparison of tanδ curves for LDPE and HDPE

Three dispersions are present in the LDPE data from the high temperature side: α, β, and γ. The α dispersion is attributed to crystal relaxation, the β dispersion is attributed to the main dispersion (glass transition) of the amorphous portion and the γ dispersion is attributed to local mode relaxation of the amorphous portion. In the HDPE data, an α’ dispersion is present, in addition to the three previously mentioned dispersions. This α’ dispersion is attributed to the grain boundary relaxation.

The figure below compares the tanδ curves of the low and high density polyethylene measurement results. The β dispersion peak of the HDPE is lower than that of the LDPE. Furthermore, the α dispersion peak for the HDPE is at a higher temperature. These results are likely due to the following reasons. High density, highly crystallized polyethylene has little main chain branching and a lower amorphous component than LDPE. This results in a lower β dispersion, which is caused by glass transition. Conversely, due to the high amount of crystal lamellae in high density polyethylene, the α dispersion (crystal relaxation), which appears along with the α’ dispersion (grain boundary relaxation), is at a higher temperature.