mixed HDPE and LDPE lamellae. The difference between the measured and calculated intensities further imply that the components are not completely separated and there must be some mixing of the two species within each lamella. However, the incorporation of as little as 15–20% LDPE within the HDPE phase (and vice-versa) would be enough to bring the experimental and calculated intensities into agreement. Thus, HDPE/LDPE blends are either completely (φ ≥ 0.5) or almost completely (φ < 0.5) phase separated into separate HDPE and LDPE lamellae over the whole compositional range after slow cooling from the melt.

B. Rapidly Quenched Blends

SANS data were also collected on blends of HDPE-D/LDPE-H, quenched from the melt into dry ice/acetone at -78°C, though these samples gave qualitatively different spectra at the LDPE-rich and HDPE-rich ends of the composition range. For LDPE-rich blends (10/90 and 23/77 wt%), a monotonic fall-off is observed as a function of Q and the data approach the Q-2 asymptote, as opposed to the Q-4 behavior observed for slowly cooled blends [eq. (1)]. This suggests that the scattering arises from individual molecules as opposed to separate phases with sharp boundaries. When the data are replotted in the Zimm or Ornstein-Zernicke format [Q2/ΔQ2 (Q) vs. Q2, the (Q = 0) calculated cross section is close to the measured value from the extrapolated intercept (Fig. 2)]. The radius of gyration (Rg = 140 Å) is similar to the molecular dimensions measured in the solid state for HDPE-D/LDPE-H blends. For all blends, SAXS shows only one feature in the Lorentz-corrected data indicating that there is a single lamellar stack. Thus, for LDPE-rich blends, the deuterated linear polymer seems to be extensively cocry stallized with the branched molecules in the lamellae.

For HDPE-rich mixtures, the form of the scattering is apparently different at first sight as indicated in Fig. 3. Data for the 80/20, 70/30, and 50/50 blends exhibit inflections, which seem to reflect the peak in the HDPE scattering. A component of the scattering from the periodic lamellar structure is always present in the blend data, though if the D-labeled and protonated molecules are randomly mixed, it normally forms a minor correction to the data. However, if the protonated molecules were preferentially located in the interlamellar amorphous regions, this would enhance the scattering length density contrast between the crystal and amorphous regions and the overall lamellar periodicity would therefore show up much more strongly in the blend cross section. For example, assuming an overall crystallinity index of 33% for the 80/20 blend, if the average concentrations in the crystal and amorphous regions were 90/10 and 75/25 respectively, the blend cross section would contain a component of 450% (-4.5) the fully deuterated “blank” cross section, which would cause observable inflections in the slopes as observed in Fig. 3. Figure 4 shows the corrected signal after subtracting 5 × the PED SANS cross section. The Zimm plot is now linear with good agreement between the measured (644 cm-1) and calculated (612 cm-1) cross sections. Thus, the blends are again extensively cocry stallized, though the branched molecules seem to be preferentially contained in the amorphous regions. The perturbation of the SANS pattern by such an excess contribution of LDPE would be much less for predominantly branched materials, as the SLD difference between the crystal and amorphous is much smaller, so no such feature is observed (Fig. 2). Thus, for rapidly quenched blends, the components are extensively cocry stallized for all concentrations. Experiments are currently in progress to explore the solid state morphology of blends of HD and LDPE as a function of quench rate, and these studies are also being extended to HD/LDPE systems.

REFERENCES


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TABLE 1. Measured and Calculated Cross Sections for HDPE/LDPE Blends Slow Cooled (0.75°C/min) From the Melt

<table>
<thead>
<tr>
<th>Nominal Wt% (HDPE/LDPE)</th>
<th>Correlation Length (Å)</th>
<th>$10^3 g(Q) / Q = 0$ (cm$^{-1}$) (exp)</th>
<th>$10^3 g(Q) / Q = 0$ (cm$^{-1}$) (calc)</th>
<th>Long Period (Å)</th>
</tr>
</thead>
<tbody>
<tr>
<td>80/20</td>
<td>63</td>
<td>7.6</td>
<td>6.9</td>
<td>299/125</td>
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<tr>
<td>70/30</td>
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<td>15.5</td>
<td>16.6</td>
<td>292/125</td>
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<tr>
<td>50/50</td>
<td>92</td>
<td>28.4</td>
<td>34.3</td>
<td>285/114</td>
</tr>
<tr>
<td>23/77</td>
<td>114</td>
<td>15.6</td>
<td>45.0</td>
<td>180</td>
</tr>
<tr>
<td>10/90</td>
<td>107</td>
<td>6.9</td>
<td>19.1</td>
<td>139</td>
</tr>
</tbody>
</table>

Figure 1
Debye-Bueche Plots for (a) 70/30 and (b) 80/20 wt % Blends of HDPE-D and LDPE-H Slow Cooled from Melt 0.75°C/min

Figure 2
$g(Q) / Q$ vs. $Q^2$ for 10/90 Sample of HDPE-D/LDPE-H

Figure 3
$g(Q) / Q$ vs. $Q$ for PED and PED-RICH Blends of HDPE-D/LDPE-H

Figure 4
$g(Q) / Q$ vs. $Q^2$ for RAPIDLY QUENCHED 80/20 BLEND OF HDPE-D / LDPE-H AFTER BACKGROUND CORRECTION BASED ON THE ASSUMPTION THAT THE LDPE RESIDES PREFERENTIALLY IN THE AMORPHOUS REGION.