Compatibilization of Blends of Recycled PA6 and PA66 with SMA® 9000P

Benefits
- *In situ* reactive compatibilization of recycled PA6 and recycled PA66 blends
- Chain extension providing improved physical/mechanical properties
- Improvements in high-temperature property retention
- Increased recycled content in new product formulations

Target Markets/Applications
- Automotive
- Industrial
- Durable goods

Description
SMA® 9000P resin (Table 1) can be used as a reactive chain extender and compatibilizer for post-industrial blends of recycled PA6 (r-PA6) and recycled PA66 (r-PA66). Commonly derived from the automotive sector, comingled streams of PA can be repurposed using SMA to reconstitute mechanical properties and heat resistance. As an additive, SMA 9000P can facilitate recycled content going back into the automotive industry for under-the-hood applications.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Mean Value</th>
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<tr>
<td>$M_w$ (g/mol)</td>
<td>~9,500</td>
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<tr>
<td>Anhydride (wt%)</td>
<td>~23</td>
</tr>
<tr>
<td>Anhydride (per chain)</td>
<td>~9</td>
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<tr>
<td>$T_g$ (°C)</td>
<td>~125</td>
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SMA 9000P was confirmed as a chain extender and compatibilizer in two distinct model formulations depicting a r-PA6 rich and a r-PA66 rich comingled post-industrial recycled stream (Table 2). Each model composition was prepared in a twin-screw extruder with 2% by weight SMA 9000P.

Table 2: Model formulations for r-PA6 rich and r-PA66 rich baseline systems.

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<thead>
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<th>Recycled PA6 (wt%)</th>
<th>Recycled PA66 (wt%)</th>
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<tbody>
<tr>
<td>Baseline 1</td>
<td>30</td>
<td>70</td>
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<tr>
<td>Baseline 2</td>
<td>70</td>
<td>30</td>
</tr>
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Chain extension promotes a reaction between anhydride groups on the SMA backbone and the terminal amino functionality characteristic of polyamides. The result is a branched structure of both r-PA6 and r-PA66 chains created \textit{in situ} that serves as a compatibilizing agent. Figures 1 and 2 demonstrate the net effect of 2% by weight addition of SMA 9000P on the ductility and Charpy impact strength of a r-PA6 and r-PA66 rich formulation, respectively.

Figure 1: Blending r-PA6 and r-PA66 reduces elongation at break and charpy impact. SMA 9000 compatibilizes the two recycled materials and improves the ductility and impact of a r-PA6 rich blend.
Figure 2: Baseline 2 has a higher elongation at break but a lower charpy impact compared to the r-PA6 and r-PA66. SMA 9000 compatibilizes the recycled materials and improve the ductility and impact of the r-PA66 rich blend.

Figures 3 and 4 demonstrate that adding only 2% by weight SMA 9000P permits the recycled polyamide compounds to retain important mechanical integrity at elevated temperatures. Tensile yield strength, flex yield strength and flex modulus are all retained in excess of the polyamide baseline formulations. The increase is attributable in part to the inherent heat resistance ($T_g = 125$ °C) of the SMA additive, and also to the crosslinking provided by chain extension. Other mechanical properties were not negatively affected.

Figure 3: Tensile yield strength retention in comigled recycled PA materials exposed to 110 °C.
Conclusion

Addition of SMA 9000P to blends of recycled polyamide provides chain extension and compatibilization through reactive extrusion. As a result, physical properties are improved both at ambient and elevated application temperatures alike. Introducing a low dosage of SMA 9000P can offer formulators flexibility to incorporate more post-industrial content and improve properties and processibility. Low dosages and incorporation of post-industrial content can even reduce the cost position of nylon compounds.

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