**TECHNICAL UPDATE**

**SMA® 9000 Series (9001, 9002) Concentrates for Polyamide Modification**

**Benefits**
- Chain extension providing improved physical/mechanical properties
- Formulated concentrates for efficient reaction at low concentrations
- Pellet form for easy process integration
- Enhanced properties in virgin and recycled streams

**Target Markets/Applications**
- Automotive
- Industrial
- Durable goods

**Description**

SMA® 9000 series concentrates are the ideal additive candidate to modify polyamides melt and mechanical properties. Relevant to both commodity polyamides (6, 6/6) and specialty (12, HTN), styrene maleic anhydride (SMA®) is an efficient chain extender that functions by tethering adjacent chains at the terminal amine group. As a result, the concept applies to virgin, recycled, blended and filled systems alike. The chain extenders are multi-functional compounds that are easily incorporated, thermally stable, non-volatile and capable of fast reaction. Characteristics such as melt strength, ductility and impact can be enhanced by introducing low doses of reactive SMA. Table 1 outlines the two first generation SMA 9000 series products, and their typical application spaces. SMA 9001 is the formulated for use in many systems, whereas 9002 was designed exclusively for more challenging recycled polyamide streams.

**Table 1:** SMA 9000 Series concentrates and their primary application spaces. SMA® 9001 is based on an LLDPE carrier, whereas SMA 9002 is based on a PP homopolymer carrier.

<table>
<thead>
<tr>
<th>Product</th>
<th>Virgin PA</th>
<th>Recycled*</th>
<th>Recycled Contaminated**</th>
<th>Blends</th>
<th>Filled Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMA® 9001</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>SMA® 9002</td>
<td>X</td>
<td>X</td>
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</tbody>
</table>

* Post industrial polyamide (PIPA), or ‘clean’ post consumer polyamide (PCPA)
** Contaminated PCPA with >5% PP and/or >10% contaminants

One of the greatest challenges that polyamides present are exceptionally low melt viscosities, which can be detrimental to productivity and applicability. Figure 1 illustrates the dramatic effect on melt flow rate for both virgin commodity polyamides, and recycled streams of PA6/6. Note how SMA 9000 Series concentrates permit the user to dial in to a prescribed melt flow rate as the application commands.
Virgin Polyamides

Widely used in many strenuous applications, polyamides in their many forms have become synonymous with performance. However, very little development has been made in industry to further differentiate polyamides. Leveraging a reactive species such as SMA 9001, new advances in augmenting melt strength, blending with other polymers, and enhancing key performance attributes can be tuned to penetrate new application spaces. Figure 2 & Figure 3 illustrate the influence of low fractions of SMA 9001 on neat PA6 & PA6/6 respectively.

Figure 1: SMA 9001 effect on melt flow of virgin PA6 (250 °C, 5.0 kg), virgin PA6/6 (280 °C, 2.16 kg) and recycled streams of PA6/6 (280 °C, 2.16 kg). Note beyond 2% by weight SMA 9001 in virgin PA6/6 was estimated due to extreme changes in flow.
Recycled Polyamides

Globally, there has been a shift to repurposing polyamide from a variety of sources, such as end of life carpet and automotive. Despite significant efforts in separation and cleaning technology, only a small fraction of recycled polyamide 6 and polyamide 6/6 can be re-introduced into their incumbent applications. Post-industrial and post-consumer polyamides tend to have lower properties than is desirable for injection molding. Figure 4 & Figure 5 outlines the effectiveness of SMA 9001 & 9002 on a purified r-PA6/6 and contaminated r-PA6/6 respectively.
Summary

SMA 9000 series concentrates are the ideal additives to effectively modify the property landscape of virgin, recycled, blended and filled polyamides. A formulated pellet provides a balance of productivity, efficiency and homogeneity when used in your existing setup. Look for additional next generation SMA concentrates to impart tensile properties in addition to those shown above.

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