A COMPARISON OF EVAL™ EVOH RESINS AND PA MXD6 RESINS

In recent years, PA MXD6 resins have been promoted in the food packaging industry as an alternative to other high barrier resins. PA MXD6 resins are semi-aromatic polyamides that, according to published information, have superior barrier properties at high humidity conditions, excellent process-ability, superior recyclability and superior thermal stability. However, the performance comparisons for PA MXD6 versus other barrier resins do not accurately represent the performance of PA MXD6 versus other high barrier materials, particularly EVOH.

Evaluations of the performance of PA MXD6 versus EVAL™ EVOH resins were recently conducted by EVAL Americas. The results of the evaluations provide a much more accurate representation of key EVAL™ EVOH resin properties.

BARRIER PROPERTIES

EVAL™ EVOH resins are highly crystalline and it is this crystallinity that provides superior barrier properties. The crystallinity in EVOH can be increased by imparting orientation (stretching) which is commonly achieved in blown film extrusion, sheet thermoforming and other processes. The higher degree of crystallinity achieved from orientation of EVOH improves the oxygen permeability, particularly at higher %RH conditions. Table 1 summarizes the oxygen permeability for multilayer oriented films with PA MXD6 and various EVAL™ grades at relative humidities between 60 and 90% films and at 23°C (73°F). The OTR performance for PA MXD6 versus the various EVAL™ grades in the multilayer oriented films is also represented graphically in Figure 1. The multilayer oriented films were prepared using co-extruded blown film (2.0 blow-up ratio) in a PE // barrier // PE structure.

PA MXD6 is inaccurately reported to have better gas barrier performance than EVOH in high humidity environments due to its lower moisture sensitivity. While it is well known that the barrier properties of EVOH resins are affected by the moisture content (relative humidity) of the EVOH layer, the data presented by the major PA MXD6 supplier does not accurately represent the performance of EVOH. EVAL™ resins provide better barrier properties than PA MXD6, even at very high relative humidity conditions.
Table 1

EVAL™ and PA MXD6 Oxygen Transmission Rates

<table>
<thead>
<tr>
<th>GRADE</th>
<th>60% RH</th>
<th>80% RH</th>
<th>90% RH</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA MXD6</td>
<td>4.2</td>
<td>6.9</td>
<td>15.6</td>
</tr>
<tr>
<td>EVAL™ L171</td>
<td>0.1</td>
<td>0.8</td>
<td>4.8</td>
</tr>
<tr>
<td>EVAL™ F171</td>
<td>0.3</td>
<td>1.0</td>
<td>4.1</td>
</tr>
<tr>
<td>EVAL™ E171</td>
<td>1.8</td>
<td>3.0</td>
<td>6.3</td>
</tr>
</tbody>
</table>

**NOTES:**
(1) OTR performance for PE // barrier // PE co-ex blown film structure - 90 micron, 2.0 BUR, films prepared and analyzed for OTR by Kuraray America Inc., EVAL Business Unit

(2) OTR performance normalized per unit thickness (20µm) of barrier material in the structure
PROCESSABILITY AND THERMAL STABILITY

PA MXD6 resins can be processed in conventional extrusions systems and can be co-extruded with polyolefins. However, due to its very high crystalline melt point (> 230°C), PA MXD6 must be processed at a much higher temperature than is typically used to process polyolefins. These higher temperatures require more electrical power and therefore result in higher converting costs. Furthermore, the higher processing temperature required for PA MXD6 has the potential to cause thermal damage to polyolefins and other polymers commonly used in co-extrusion processes. EVAL™ resins are also easily processed in conventional thermoplastic extrusion systems and can be coextruded with all types of polyolefins and other polymers. EVAL™ resins provide good thermal stability at processing temperatures commonly used for many polyolefins. EVAL™ resins also provide stable viscosity stability with respect to time, even when subjected to high shear and high temperature. Figure 3 below compares the change in viscosity with respect to time (dynamic viscosity stability) for both EVAL™ L171B (27 mol% ethylene) and PA MXD6. Figure 4 below is a photograph of the recirculating micro twin screw extrusion system for measuring axial force to determine the viscosity stability of the resins. PA MXD6 yields a steady increase in viscosity over time (cross linking) whereas L171B yields a very mild decrease (degradation) in viscosity over time. The mild decrease in viscosity exhibited by L171B and other EVAL™ grades yields lower gel formation over time, particularly in co-extrusion barrier applications that utilize regrind.

Figure 3
Viscosity Stability of EVAL L171B versus PA MXD6
RECYCLABILITY

One of the serious economic concerns in coextrusion is the loss of trim scrap or flash. Due to the use of vastly different and/or thermally sensitive polymers, many multi layer structures can be difficult or impossible to reprocess. Multi layer structures containing EVAL™ resin can be readily recovered and reused. Regrind containing up to 15% EVAL™ resin can be used as a distinct layer in a multi layer structure. PA MXD6 was reported to have superior recyclability versus EVOH; however, a recent examination of the relative performance indicates that PA MXD6 does not provide superior recyclability. Figure 5 below shows a lower tendency for gel formation for EVAL™ L171B versus PA MXD6 in a repeated extrusion test.
SUMMARY

EVAL™ EVOH resins provide superior oxygen barrier to PA MXD6 and other barrier materials even at high relative humidity conditions. Many common converting processes such as blown film and thermoforming impart additional crystallinity in EVAL™ resins which further improves the oxygen permeability, particularly at higher %RH. EVAL™ resins provide good viscosity stability over time in co-extrusion systems that yield lower gel formation over time. EVAL™ resin can be recycled and have a lower tendency for gel formation versus PA MXD6 in repeated extrusion tests.